NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ANALYSIS OF CURRENT DEPARTMENT OF DEFENSE RISK MANAGEMENT PRACTICES IN WEAPON SYSTEM ACQUISITION: A CASE STUDY OF THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PDRR AND SDD RISK MANAGEMENT PRACTICES

by

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This thesis discusses risk in Department of Defense (DoD) weapon systems acquisition. It uses the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV) as a case study in risk management strategy and techniques.

The AAAV will provide the Marine Corps with a fast deploying, over-the-horizon, waterborne insertion capability. The AAAV's improvements over the currently fielded Amphibious Assault Vehicle (AAV) will provide Marines with a highly survivable and lethal weapon system ashore.

Risk is the possibility of damage, injury or loss. The severity of a risk is determined by a combination of both the probability of an unfavorable event occurring and the severity of the event's occurrence.

Risks are present in virtually all DoD developmental programs. Programs suffer from risks in technical challenges, unstable system requirements, missing schedule milestones, unpredictable funding and cost overruns.

The DoD currently uses techniques to mitigate risks inherent in advanced system development. This thesis analyzes the AAAV's Program Definition and Risk Reduction (PDRR) acquisition phase risk management strategy. The thesis concludes by drawing from the lessons learned in the AAAV program during PDRR and analyzing the application of the lessons learned during the AAAV's current acquisition phase, System Development and Demonstration (SDD).

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I. INTRODUCTION

A. PURPOSE

This thesis examines the Department of Defense (DoD) system acquisition risk management environment by analyzing the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV) program. To conduct this analysis, this thesis will discuss risk in the context of DoD development and procurement, current risk management practices in DoD and in the defense industry, and introduce the AAAV system to briefly familiarize the reader with the program. The analysis will concentrate on the AAAV Program Definition and Risk Reduction (PDRR) Acquisition phase. This thesis will discuss the AAAV's System Development and Demonstration (SDD), the current Acquisition Phase, risk management strategy with respect to lessons learned during PDRR. This thesis will conclude by examining the AAAV's SDD risk management practices and providing recommendations for managing risk in developmental weapons system acquisition based on the AAAV's experiences.

B. BACKGROUND

Risk is the possibility of injury, damage or loss. In DoD systems acquisition, risks are the "chances of not achieving the results as planned." (Forsberg, Mooz and Cotterman, 2000, p. 188) In weapon system development and procurement, planned results are meeting operational deficiencies throughout DoD on time, on budget and to a satisfactory performance level. The failure to satisfy the war fighter's requirements can result in decreased effectiveness of the United States DoD.

Risk is the "probability or likelihood of failing to achieve a particular outcome" and "the consequence or impact of failing to achieve that outcome." (Defense Acquisition University (DAU), Risk Management Guide for DoD Acquisition, 2001, p. 5) A level of risk is determined by combining both the probability of the undesirable event occurring and the impact, or severity, of the event. There are many categories of risk. This thesis discusses technical risk, requirements risk, schedule risk and cost/funding risk.

The DoD acquisition regulations are undergoing change at the time this thesis is being written. The AAAV program executed its risk management strategy based on then current DoD acquisition guidelines and regulations. This thesis discusses risk management practices designed to reduce, eliminate, transfer and accept risk in developmental programs. The purpose of this research and analysis is to present the risk management techniques the AAAV program has benefited from most. Additionally, this thesis will discuss which aspects of the program's PDRR risk management strategy have led to the adoption of different techniques in SDD and discuss why. The overall benefit of this research is to familiarize the reader with successful risk management practices in DoD acquisition.

C. RESEARCH QUESTIONS

The primary research question this thesis addresses is:

- How have the lessons learned from the AAAV's Program Definition and Risk Reduction (PDRR) Risk Management Strategy impacted the Program's Risk Management Process during System Development and Demonstration (SDD)?

In order to answer the primary research question, this thesis will answer the following subsidiary questions to provide the necessary background information:

- What are risk and risk management in Department of Defense (DoD) systems acquisition?
- What techniques can DoD use to manage risk in developmental systems?
- What is the AAAV program?
- What are the lessons learned from the AAAV PDRR Risk Management Strategy?
- What risk management approaches has the AAAV Program Office adopted to manage technical and programmatic risk during SDD?
- What conclusions and recommendations can be drawn from this analysis?

D. RESEARCH METHODOLOGY

This author's research methodology included extensive literary and Internet searches. The primary forms of literature used were DoD publications and guidelines, magazine articles and textbooks. The Internet provided a great deal of information on DoD risk management techniques and on the AAAV. Of greatest benefit to the research was the opportunity to visit the AAAV program office in Virginia. This author was able to interview Government program office as well as Prime Contractor personnel. The information and insights were invaluable to this effort.

E. ORGANIZATION OF THE STUDY

This thesis is organized into six chapters. A brief description of the chapters' content follows.

Chapter I introduces the thesis and the primary and subsidiary thesis questions. The purpose of this chapter

is to provide a snapshot of the thesis and its intended benefit to readers.

Chapter II provides background information on the DoD risk management environment. The chapter offers the reader the information necessary to better appreciate subsequent chapters. Chapter II discusses types of risk commonly encountered in defense acquisitions and presents risk management techniques used in weapon system procurement and development.

Chapter III provides the reader with background information on the AAAV system and its acquisition history to date. The purpose of Chapter III is to familiarize the reader with the challenges and complexities of developing a system like the AAAV.

Chapter IV discusses the AAAV PDRR risk management techniques. This chapter presents the data to be analyzed. The chapter will focus on five areas of risk management in the AAAV program during PDRR:

- Information Technology Tools
- Risk Management Process
- Managing Risk Through the Contracting Process
- Government and Prime Contractor Co-location
- Test and Evaluation

Chapter V analyzes the AAAV PDRR risk management strategy and introduces elements of the AAAV SDD risk management plan based on PDRR lessons learned.

Chapter VI concludes the thesis by summarizing how the lessons learned from the AAAV's PDRR risk management strategy have helped shape the program's current risk

management practices in SDD. The thesis closes by presenting recommendations for managing risk in DoD acquisition programs and offering areas for further research and study in DoD acquisition risk management.

F. SUMMARY

The purpose of this chapter is to provide the reader with an overview of this thesis. The benefit of this research and analysis is to highlight successful risk management techniques in complex, developmental weapon systems. The techniques and procedures may have application to managing risk in any program or organization.

The next chapter provides background information on the DoD risk management environment.

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II. BACKGROUND

A. INTRODUCTION

This chapter defines risk in the context of Department of Defense (DoD) program management and systems acquisition. The chapter then analyzes the risk management and risk mitigation processes in DoD. It addresses the importance of striking a balance between risk acceptance and risk mitigation in a developmental weapon system program. This chapter concludes by exploring different risk management techniques commonly used throughout the DoD acquisition environment.

B. RISK IN THE DEPARTMENT OF DEFENSE

Risk is the possibility of injury, damage or loss. In program management, risks are the "chances of not achieving the results as planned." (Forsberg, Mooz and Cotterman, 2000, p. 188) With rapid technological growth and emerging, complex mission needs, risk exists in virtually all of today's DoD developmental weapons systems. In Defense Acquisitions, loss refers to the impact of the risk to a program, which could be in the form of diminished performance, increased costs or schedule delays. Risk is the "probability or likelihood of failing to achieve a particular outcome" and "the consequence or impact of failing to achieve that outcome." (Defense Acquisition University (DAU), Risk Management Guide for DoD Acquisition, 2001, p. 5)

Risk, whether programmatic, technical, managerial, etc., is present in DoD developmental systems. Numerous

risk areas exist in the acquisition environment, each posing a threat to the success of a program.

1. Types of Risk

Risks are future events that may or may not occur. In DoD acquisitions, risks are future events that may adversely affect a program's cost constraints, schedule or performance requirements. The types of risk are often interrelated and are not always obvious.

> Risks are in the Program Management Office (PMO) (program plans, etc.); in support provided by other Government agencies; in threat assessments; and in prime contractor processes, engineering and manufacturing processes, and technology. (Risk Management Guide for DoD Acquisition, 2001, p. 6-7)

A Program Manager (PM) is faced with a wide assortment of risk types in a program. Identifying risk in a program is a vital step in managing the potential, negative impacts of risk. Risk analysis is the "process of examining each identified risk area to refine the description of the risk, isolating the cause, and determining the effects." (Guidelines for Successful Acquisition of Software-Intensive Systems (GSAM), 2000, p. 6-18) Before risk analysis and mitigation can be discussed, several types of risks that programs often face must be analyzed.

Sources of risk can be generally classified, but are not limited to, one of the following categories: technical risk, requirements risk, schedule risk and cost/funding risk. (Risk Management Guide for DoD Acquisition, 2001, p. 7)

a. Technical Risk

Technical risk is the "degree to which the technology proposed for the program has been demonstrated as capable of meeting all of the program's objectives." (Risk Management Guide for DoD Acquisition, 2001, p. 8) Technical risk refers to the maturity level of technology utilized in the system being developed. The main concern with technical risk is that the system will fail to perform to expected standards because of immature or poorly integrated technology. In software development, a great technical risk lies in the difficulty in measuring developmental progress through the use of Technical Performance Measurements (TPM). TPMs are metrics that a PM may use to measure progress in a program. Many TPMs used in DoD lend themselves to physical measurements: weight, height, voltage, power, etc. Given modern systems' reliance on software to achieve technical objectives, an inability to accurately monitor software development progress by means of a concrete TPM will continue to pose a great technical risk to a developmental program.

b. Requirements Risk

The requirements generation process produces information for decision makers on the projected mission needs of the war fighter. A system evolves from the President's National Security Strategy (NSS), DoD's National Military Strategy (NMS), through several layers of analysis and refinement until the issuance of the Mission Needs Statement (MNS). The MNS defines, in broad, general terms a deficient operational capability based on threat assessments.

Mission needs are defined in broad operational terms in a Mission Needs Statement (MNS) document. Based on the MNS, services conduct Analyses of Alternatives (AoA) to assess the potential for application of fielded, DoD systems to meet the emergent requirement. If no suitable alternative exists within DoD, an Operational Requirements Document (ORD) is issued which initiates the development of a new system. (Systems Engineering Fundamentals, 2001, p. 45) Requirements definition is vital to establishing and adhering to a strict timeline or schedule for the program.

The Requirements Generation Process is one of three elements in the DoD's principal decision support system. The system results in "identifying and documenting war fighting needs based on current or future mission deficiencies or technological opportunities." (Systems Engineering Fundamentals, 2001, p. 27) Figure 1 illustrates the evolving Requirements Generation Process from the issuance of the ORD through system fielding.

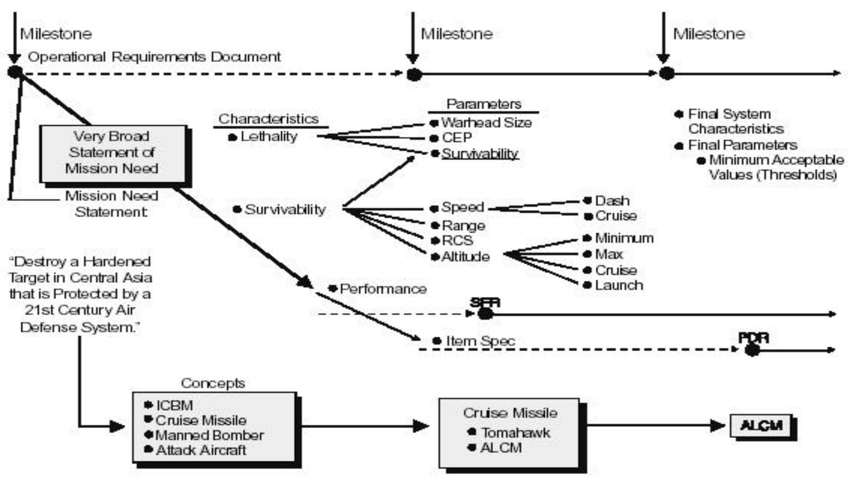


Figure 1. Requirements Generation Process, from (Test and Evaluation Management Guide, 2001).

Ensuring that a system’s requirements can be identified and established early and accurately greatly reduces the risk of requirements creep. Figure 2 illustrates how the Requirements Generation Process overlaps with Acquisition Management and the Planning, Programming and Budgeting System (PPBS) and is a crucial element to the system development process.

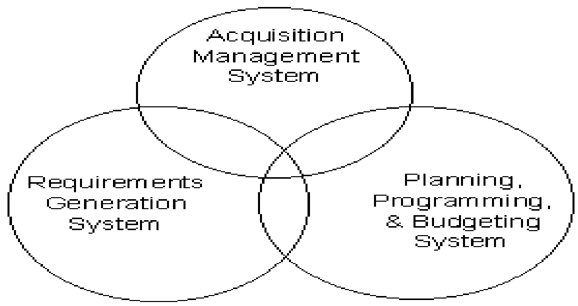


Figure 2. Three DOD Decision Support Systems, from (CJCSI, 2001).

The risk associated with a requirement is linked to the variability of the requirement. “Creeping” or changing requirements can lead to schedule delays and can significantly impact a program. Requirements risk is the “sensitivity of the program to uncertainty in the system description and requirements.” (Risk Management Guide for DoD Acquisition, 2001, p. 7)

The ORD is reviewed several times throughout the life of a program. Each review may alter original requirements, which can initiate time consuming and costly Engineering Change Proposals (ECP). Such changes can negatively impact a program’s cost and schedule. Figure 3

shows the interface between the system lifecycle and the requirements analysis process.

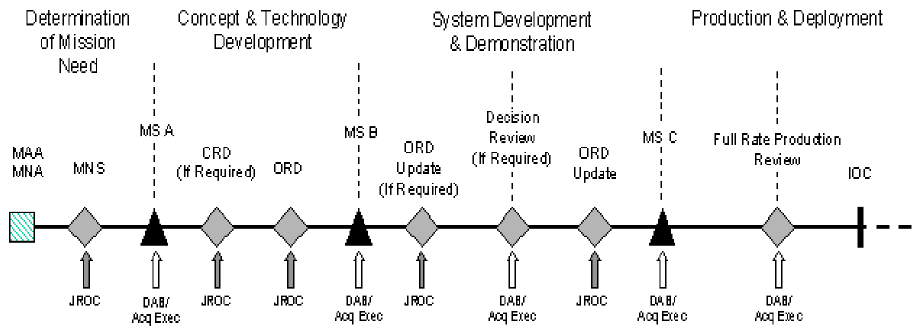


Figure 3. Current Requirements and Acquisition Interface, from (CJCSI, 2001).

The current requirements and acquisition interface contains significantly fewer opportunities to impact a program based on creeping mission requirements than the previous acquisition process; however, changing requirements at any time introduces the risk of costly design changes. Design changes late in a program’s life can be technologically challenging and costly to the Government.

Requirements risk may occur as a result of any of the following:

- Operational requirements not properly established or vaguely stated for program phase
- Requirements are not stable
- Required operating environment not described
- Requirements do not address logistics and suitability
- Requirements are too constrictive-identify specific solutions that force high cost (GSAM, 2000, p. 6-29)

Without adequate and stable requirements definition early in the life of the program, the Program Management Office (PMO) may be forced to make costly changes in the system.

c. Schedule Risk

Program Managers are evaluated on the cost, schedule, and performance of their program. (DoD 5000.2-R, 2002, pp. 21, 24) Many acquisition programs are driven by time, or schedule, rather than by significant events or milestones in the program's progress. Many factors can influence a program's ability to adhere to a specific schedule. Schedule risk is the "adequacy of the time allocated for performing the defined tasks, e.g., developmental, production, etc. This factor includes the effects of programmatic schedule decisions, the inherent errors in the schedule estimating technique used, and external physical constraints." (Risk Management Guide for DoD Acquisition, 2001, p. 8)

Virtually every risk area can degrade a program's ability to maintain a schedule. In the design of a system, reliance on immature technology or an unproven development process can cause a program's schedule to slip. If logisticians are not involved in the early system development process, inadequate supportability late in development or after fielding can result in the necessity to make engineering changes causing delays in the system's Initial Operational Capability (IOC).

Pressure exists for a PM to establish an acquisition lifecycle schedule early in the system's life and to maintain that schedule throughout. Development time

estimates are based on several factors including parallel, or like-system development and contractor estimates. Department of Defense policy concerning acquisition schedule is as follows:

> Schedule parameters shall minimally include (in Acquisition Program Baseline (APB)) dates for program initiation, major decision points, and the attainment of initial operating capability (IOC). The PM may propose, for Milestone Decision Authority (MDA) approval, other, specific, critical, system events, as necessary. (DoD 5000.2-R, 2002, p. 22)

A program's risk of experiencing a schedule delay is compounded, for example, by the development and integration of new technologies, changing requirements and budget constraints, among others. A program unable to comply with an approved schedule may risk cancellation.

d. Cost/Funding Risk

Without funding, a program has no life. A detailed, total ownership cost (TOC) estimate is required upon initiation of a program. DoD guidelines are specific in their direction concerning the establishment of detailed cost estimates:

> Cost parameters shall identify TOC (broken-out into direct costs: research, development, test, and evaluation costs, procurement costs, military construction costs, operating and support costs (to include environmental, safety, and occupational health compliance costs), and the costs of acquisition items procured with operations and maintenance funds, if applicable. Cost figures shall reflect realistic estimates of the total program, including a thorough assessment of risk. (DoD 5000.2-R, 2002, p. 23)

A PM clearly needs to provide an accurate, sound estimate on the TOC of the program before system

development begins. The risk is the inability to accurately predict costs given uncertainty at the outset of a program. The cost risk area is whether a program has "the ability to achieve the program's life cycle cost objectives. This includes the effects of budget and affordability decisions and the effects of inherent errors in the cost estimating technique(s) used (given that the technical requirements were properly defined)." (Defense Acquisition University, 2001, p. 8)

Technical, requirement, schedule and cost/funding risks are but a few examples of many risk areas prevalent in defense acquisitions. To summarize the impact of each risk area and the interrelatedness of each, the Government Accounting Office (GAO) wrote in a report regarding acquisition risk:

> Once in a product development environment, external pressures to keep the program moving (such as preserving cost and schedule estimates to secure budget approval) become dominant. If a program manager decided that an additional year was needed to reach the desired level of technical maturity during the risk reduction/concept demonstration phase, the planned start of the engineering and manufacturing development phase could be delayed. This delay could jeopardize funding for that phase, thus risking the funding support for the entire program. (United States General Accounting Office, 2000, p. 16)

Programs exist because a need or requirement exists to better support or equip war fighters. All the numerous risks surrounding a defense acquisition program threaten the DoD's ability to respond to a specific mission need or leverage emerging technologies and improve our

current war fighting capabilities. Therefore, it is imperative that program managers actively manage and mitigate risks in programs. The next section discusses risk management techniques in DoD.

C. RISK MANAGEMENT

While risk is the probability of a future event occurring and the impact of that event, risk management is concerned with "the outcome of future events and how to deal with uncertainty." (Risk Management Guide for DoD Acquisition, 2001, p. 1) Throughout DoD, risk management is recognized as a vital management tool that spans the entire acquisition lifecycle from concept exploration to operations and support. (GSAM, 2000, p. 6-4) If implemented early into a program's management, risk management becomes a way of life. The key to successfully managing risk is planning and forward thinking.

> To support these efforts, assessments should be performed as early as possible in the life cycle to ensure that critical technical, schedule and cost risks are addressed with mitigation actions incorporated into program planning and budget projections. (Defense Systems Management College, 2001, p. 2-3)

The remainder of this section will discuss risk management practices and techniques commonly used in DoD.

This thesis will break down and analyze risk management in four parts: (1) Risk Planning, (2) Risk Assessment, (3) Risk Mitigation, and (4) Risk Tracking. (Defense Acquisition Deskbook (DAD), 2002)

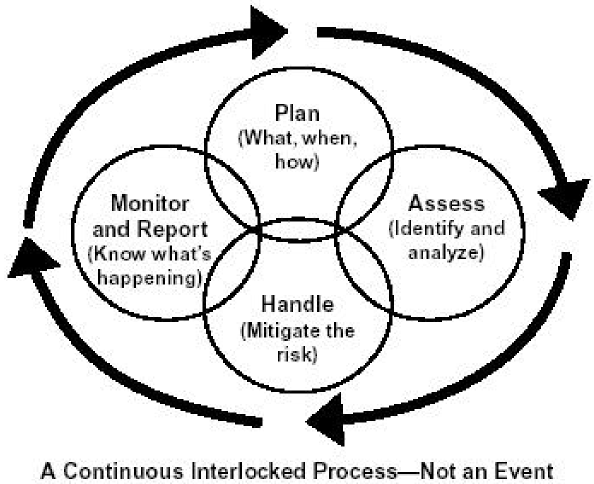


Figure 4. Risk Management Continuum, from (DAU, Systems Engineering Fundamentals, 2001).

1. Risk Planning

Risk planning is the process of "developing and documenting an organized, comprehensive and interactive strategy and methods for identifying and tracking risk areas, developing risk-mitigation plans, performing continuous risk assessments to determine how risks have changed or what new risk exists." (GSAM, 2000, p. 6-11) Planning for adequate resources is vital to implementing a risk management plan throughout the entire lifecycle of the program. The DoD 5000.2-R mandates that PMs include risk management in the acquisition strategy.

Risk planning is a continuous effort throughout the life of a program. Risk planning is not a single event. (Systems Engineering Fundamentals, 2001, p. 134) Initial planning includes "establishing a strategy; establishing goals and objectives; planning assessment, handling and monitoring activities; identifying resources, tasks and

responsibilities and establishing a method to document and disseminate information on a continuous basis." (Systems Engineering Fundamentals, 2001, p. 135) An example Risk Management Plan (RMP) outline is depicted in Figure 5 below:

Introduction
Program Summary
Definitions
Risk Management Strategy and Approach
Organization
Risk Management Process and Procedures
Risk Planning
Risk Assessment
Risk Handling
Risk Monitoring
Risk Management Information System, Documentation and Reports

Figure 5. Risk Management Plan Outline/Format, from (Systems Engineering Fundamentals, 2001).

An important aspect of risk planning is the identification of shortfalls, whether technical expertise or resources. Identifying shortfalls allows a program office to identify risk areas that may require additional augmentation or tracking. The RMP should be fully integrated into the program Acquisition Strategy. Within the framework of the Integrated Product and Process Development (IPPD) concept, assigning a Risk Management Coordinator (RMC) to a program office provides the team a focal point for risk management who is responsible for implementing and supervising the risk management process.

Once the RMP has addressed the risk management strategy and organization, the next step is to identify or assess program risks. The next section will discuss Risk Identification/Assessment.

2. Risk Identification/Assessment

Risks can be viewed as opportunities. "Risk and opportunity go hand in hand. Success cannot be achieved without some degree of risk." (Carnegie Mellon Software Engineering Institute (SEI), 1999, p. 3) Opportunities are defined as "chances for progress or advancement" or "chances for improving the value of the project results." (Forsberg, Mooz, Cotterman, 2000, p. 188) Programs and PM's risk failure when they fail to identify program risks.

> One of the biggest problems a project manager faces is motivating team members to identify risks. You want to make everyone risk conscious. However, there is often that hesitancy to surface risks, lest one be labeled a worrier or negative thinker. You can't mitigate it (risk) if you don't know it's there so it's better to anticipate a lot of problems, some of which won't happen, than too few and miss the "project killers." (Forsberg, Mooz, Cotterman, 2000, p. 193)

This section discusses risk identification and assessment.

Risk identification begins by compiling the program's risk events. Examining each Work Breakdown Structure (WBS) product and process element in terms of the sources or areas of risk most easily identifies risk events. (Systems Engineering Fundamentals, 2001, p. 11)

A WBS is a "means of organizing system development activities by examining the physical and architectural qualities of a system." (Systems Engineering Fundamentals, 2001, p. 85) The WBS enables PM's to identify potential risk areas in development and system integration.

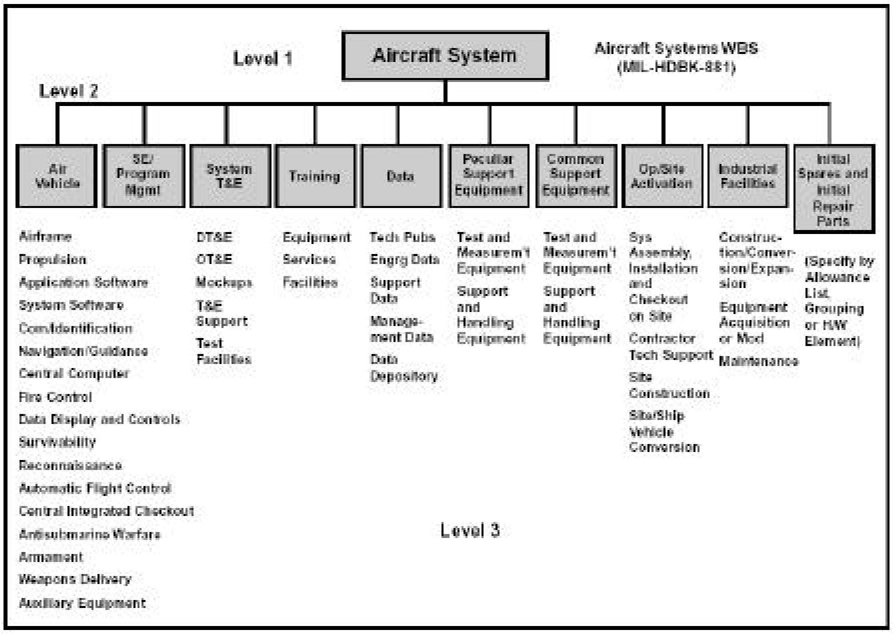


Figure 6. Example Work Breakdown Structure, from (Systems Engineering Fundamentals, 2001).

The WBS enables an entire system to be visualized through a "logical breakdown of product elements into work packages." (Systems Engineering Fundamentals, 2001, p. 86) Once risk areas are identified, a PM needs to categorize and prioritize risks elements in the program.

a. Risk Analysis Process

Through the IPPD process, program planners, engineers, logisticians and other functional area representatives discuss and analyze identified risk areas. The analysis includes determining the likelihood that a risk area will occur and the impact of the occurrence. Many tools exist to assist in this process. A risk matrix is a helpful tool to assess risk areas in programs.

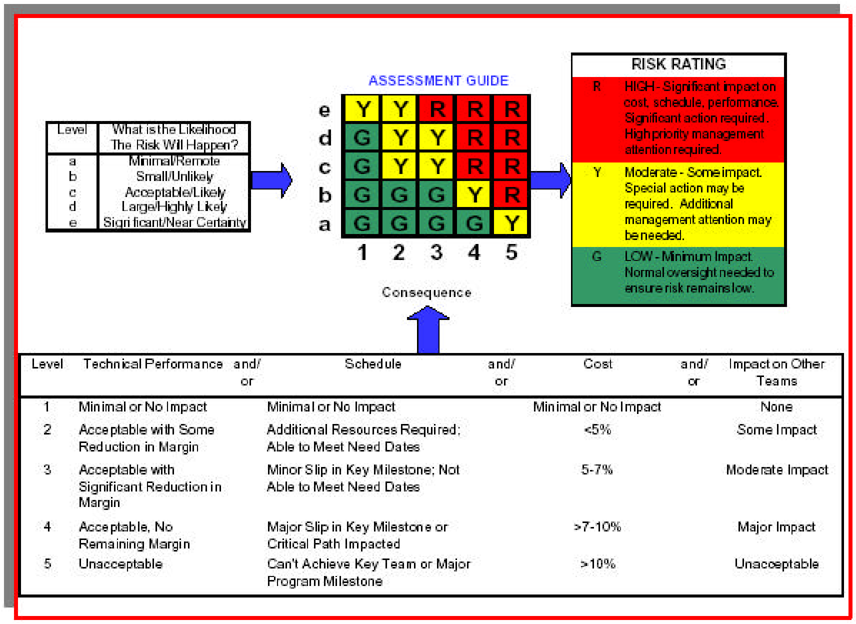


Figure 7. Example Risk Matrix, from (GSAM, 2000).

The matrix enables a PMO to individually analyze risk areas, determine the likelihood of occurrence and assess the impact of the risk on the program's cost, schedule or performance.

Risk assessments are categorized green, amber or red in ascending criticality. A PMO may elect to pay greater attention to amber or red items throughout the risk mitigation process than low risk, or "green" risks. Critical, or red, risks may be deemed unacceptable to a program and generate engineering change proposals (ECP) or an aggressive mitigation strategy to reduce the risk to an acceptable level.

The assessments for probability of risk occurrence are based on program office personnel experience, similar or parallel system development,

modeling and simulation, like-component mean time to failure and technology maturity, among others. The risk impact assessment is similarly determined. The following provides examples of risk impact determination criteria:

- Comparisons with similar systems,
- Relevant lessons-learned studies,
- Experience,
- Results from tests and prototype development,
- Data from engineering or other models,
- Specialist and expert judgments,
- Analysis of plans and related documents,
- Modeling and simulation,
- Sensitivity of analysis of alternatives. (Risk Management Guide for DoD Acquisition, 2001, p. 15)

Once the risk area probabilities and impacts are determined, the risks may be prioritized and rated based on greatest probability of occurrence and impact to the program.

b. Risk Rating and Prioritization

Risk ratings are indications of potential impact of risks on a program. Risks are often rated and categorized as High, Moderate or Low. Risk ratings and prioritization are considered an integral part of risk analysis. Prioritizing risks is the first step in developing a risk mitigation strategy, focusing efforts first on risks that carry the greatest potential impact on the program. Several tools exist to assist the PMO to make preliminary judgments regarding risk classification.

	Low Risk	Moderate Risk	High Risk
Consequences	Insignificant cost, schedule, or technical impact	Affects program objectives, cost, or schedule; however cost, schedule, performance are achievable	Significant impact, requiring reserve or alternate courses of action to recover
Probability of Occurrence	Little or no estimated likelihood	Probability sufficiently high to be of concern to management	High likelihood of occurrence
Extent of Demonstration	Full-scale, integrated technology has been demonstrated previously	Has been demonstrated but design changes, tests in relevant environments required	Significant design changes required in order to achieve required/desired results
Existence of Capability	Capability exists in known products; requires integration into new system	Capability exists, but not at performance levels required for new system	Capability does not currently exist

Figure 8. Example Risk Classification Matrix, from (Systems Engineering Fundamentals, 2001).

The documented, prioritization is called a risk Watch List. (Risk Management Guide for DoD Acquisition, 2001, p. 17) A prioritized watch lists allows the PMO to visualize risk areas and concentrate management and leadership efforts where they are most needed.

Priority	Area/Source Process	Location	Risk Event	Proba-bility	Conse-quence	Risk Rating
1	Design	WBS 3.1	Design not completed on time	Very likely	Severe	High
2						
3						

Figure 9. Example Risk Rating Matrix, from (Risk Management Guide for DoD Acquisition, 2001).

Based on identified risk areas and their probability of occurrence and impact to the program, the PMO can develop a mitigation strategy.

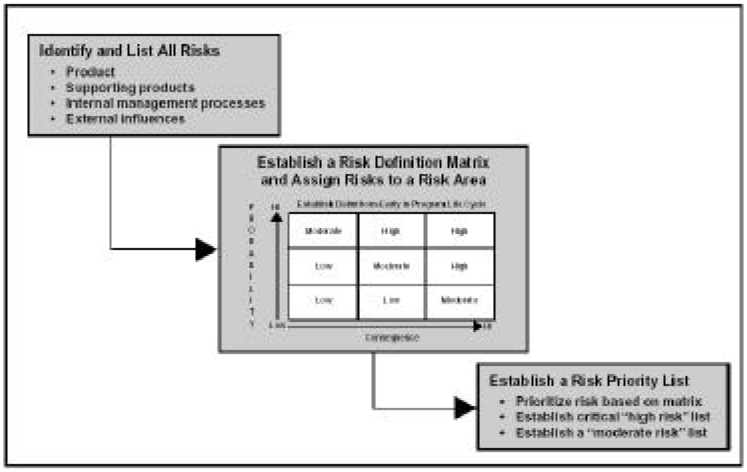


Figure 10. Initial Risk Identification and Prioritization, from (Risk Management Guide for DoD Acquisition, 2001).

3. Risk Mitigation

Risk mitigation is the process that "identifies, evaluates, selects, and implements options in order to set risk at acceptable levels given program constraints and objectives." (GSAM, 2000, p. 6-19) Risk mitigation includes determining what should be done to manage a particular risk, how often it should be done and reported, who is responsible for handling it and what the cost impact of managing the risk is. PM's must determine the possible "consequences of action or inaction as well as conducting a cost-benefit analysis of mitigation actions." (GSAM, 2000, p. 6-20) Risk mitigation actions should also be closely tied to metrics that measure the success, progress or failure of a particular mitigation action.

A program's RMC has several options regarding risk handling. RMCs may assess risk mitigation proposals based on the following criteria:

- Can the option be feasibly implemented and still meet the user's needs?
- What is the expected effectiveness of the handling option in reducing program risk to an acceptable level?
- Is the option affordable; based on both fiscal and time constraints?
- What effect, if any, does the option have on the system's technical performance? (Risk Management Guide for DoD Acquisition, 2001, p. 19)

Based on the assessments, the PMO may choose among several risk mitigation (i.e. handling) techniques.

a. Risk Avoidance

A PMO may avoid a risk of one alternative by choosing another, less risky alternative. This process is, in essence, a method to reduce risk since it does not completely eliminate risk. An important distinction to make is that risk avoidance must be a conscious decision to choose lower versus higher risk options. Avoiding risk by ignoring its presence and potential impact is an unacceptable solution.

Risk avoidance may be done in parallel with "the up-front requirements analysis, supported by a cost per requirement trade study. The concept of Cost as an Independent Variable (CAIV) is an example of such a study. It is imperative that user representatives are present during any trade-off study or decision." (Risk Management Guide for DoD Acquisition, 2001, p. 20)

Risk cannot be altogether avoided. Remembering that a risk represents an opportunity, risk aversion can lead to a poor managerial environment.

> A risk-averse culture inhibits risk management more than does the lack of a management infrastructure or a repeatable method. Such a culture generally rewards crisis management and punishes those who identify why the project may not succeed. (GSAM, 2000, p. 6-19)

It is evident that the avoidance of one risk in favor of another, less-risky alternative is not the same as attempting to eliminate risk from a program altogether.

b. Risk Control

Risk may be controlled through the continuous monitoring and correction of risky conditions. Risk control "monitors and manages the risk in a way that reduces the probability and impact of its occurrence on the program." (Risk Management Guide for DoD Acquisition, 2001, p. 19) Risk control involves reviews, inspections, risk milestone reviews, development of fallback positions and similar management techniques. Controlling risk involves "developing a risk reduction plan and then tracking to that plan." (GSAM, 2000, p. 6-20) The following lists examples of risk control actions:

- Multiple development efforts
- Alternative designs
- Early prototyping
- Incremental development
- Technology maturation efforts.
- Use of mock-ups, and
- Modeling and simulation (Risk Management Guide for DoD Acquisition, 2001, p. 19-20)

While this is not an exhaustive list, it provides examples of risk control actions while, again, not eliminating risk. All of these methods reduce unnecessary risks while working to meet user requirements.

c. Risk Assumption

Risk assumption involves a conscious decision to accept a risk level and potential impact of occurrence without taking any steps to manage or reduce the risk. The challenge for PMs lies in determining an acceptable level of risk. Risk assumption is best reserved for low-level risks, in terms of impact, or risks whose probability of occurrence is remote. Whenever possible, PMOs will handle risk assumptions by ensuring that a contingency plan is in place to address and handle emerging risks previously assumed in the program. A management reserve, additional funds, personnel or schedule time, must be in place to accomplish contingency management actions. (Risk Management Guide for DoD Acquisition, 2001, p. 21)

d. Risk Transference

Risk transference involves more than one entity sharing risk, which is often cost risk. This technique is frequently used between the Government and contractors. The Government provides a contractor financial incentives (award fees, contractual incentives), for example, to share in managing risk. A contract between the Government and a prime contractor generally initiates the risk transference process. The Government may provide financial incentives to a prime contractor to minimize or reduce risks in numerous risk areas to include system technical performance, development cost and adherence to schedule.

This thesis discusses risk transference through the contracting process in subsequent chapters.

4. Risk Tracking/Monitoring

Risk monitoring is the continuous process of "tracking and evaluating the risk management process by metric reporting, enterprise feedback on watch list items and regular enterprise input on potential developing risk areas." (Systems Engineering Fundamentals, 2001, p. 139) The process involves evaluating how current and past risk handling actions compare with previously established risk management metrics. Program metrics are used for formal analyses of how well the various development processes are progressing in comparison to TPMs, schedule predictions, technology maturity, etc.

The purpose of monitoring and tracking risk is two-fold. First, to determine if risk elements are in danger of adversely affecting cost, schedule or performance of the program. Second, risk monitoring aids in identifying risk areas not initially identified and assessed. The "Goal, Question, Metric paradigm" (GQM) is a simple example of the risk tracking/monitoring process. (GSAM, 2001, p. 6-21)

The GQM method consists of the following steps. The first step is to select the goals of the risk area-monitoring program. The second step is to identify "the questions that should be asked to determine if the goals are being met." (GSAM, 2001, p. 6-21) The final step is to identify metrics or indicators that allow one to answer the question, "Are the goals being met?" (GSAM, 2001, p. 6-21)

The final step in the risk tracking/monitoring process is to document the findings. A program office-wide shared

database allows all PMO personnel to update risk area progress and emergent threats in the program. Documentation “provides the basis for program assessments and updates as the program progresses.” (Risk Management Guide for DoD Acquisition, 2001, p. 21) Proper risk documentation also helps to incorporate new personnel into the program office and reduces the hazard of repeating past mistakes. Depending on the technical depth and size of a program, PMs will establish a standard list of risk documentation to be presented at established intervals. The following list illustrates example reports:

- Program metrics
- Technical reports
- Earned Value (EV) reports
- Watch list
- Schedule performance report
- Critical risk process reports (Risk Management Guide for DoD Acquisition, 2001, p. 22)

The above list provides examples of reports that may be used to document the implementation of the RMP to assess its successes or shortfalls. The next section will analyze several techniques that DoD can use to manage risk in developmental systems.

D. DEPARTMENT OF DEFENSE RISK MANAGEMENT TECHNIQUES

Many risk management techniques are available to the DoD. The DoD 5000.2-R requires PMs to ensure that contractors’ management information systems used in “planning and controlling contract performance meet the Earned Value Management Systems (EVMS) guidelines.” (DoD 5000.2-R, p. 49) The Program Milestone Decision Authority (MDA) may waive the requirement, in some instances. Other than EVMS, no particular risk management technique is

mandatory in DoD. This section discusses several risk management options available to PMs.

1. Test and Evaluation (T&E)

Periodic Test and Evaluation (T&E) events early and throughout a program's development are a method of evaluating the progress and technological maturity of a system and identifying new risk areas. A test plan is a risk reduction method if implemented early. The T&E process is "an integral part of the systems engineering process which identifies levels of performance and assists the developer in correcting deficiencies." (Test and Evaluation Management Guide, 2001, p. 1-1)

T&E is an important risk management technique because it helps developers and managers evaluate levels of technical performance, reliability, maintainability, technical maturity and cost and schedule conformance. T&E is a proactive measure that validates earned levels of performance and identifies emerging risks so they may be managed and tracked:

> Correcting defects in weapons has been estimated to add from 10-30% to the cost of each item. Such costly redesign and modification efforts can be reduced if carefully planned and executed test and evaluation programs are used to detect and fix system deficiencies." (Test and Evaluation Management Guide, 2001, p. 1-1)

T&E, though often costly and time-consuming to perform, has the potential to help control costs and ensure a desired level of system performance in the long run of the program. Figure 11 illustrates the relationship between committing program dollars to thoroughly test and

evaluate the system incrementally throughout its life and the life-cycle cost of the system.

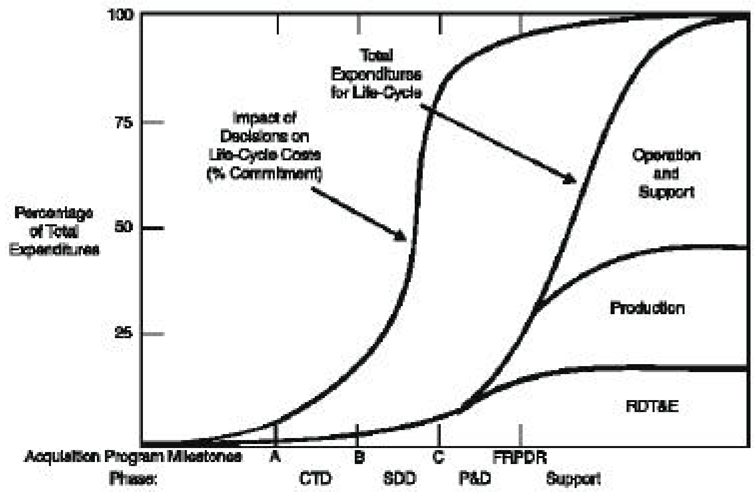


Figure 11. Life-Cycle-Cost Decision Impact and Expenditures, from (Test and Evaluation Management Guide, 2001).

The figure demonstrates that a system that is not properly tested early during its life cycle may incur far greater Operations and Support (O&S) costs than a system that undergoes a thorough T&E plan to identify and manage risks early throughout system development and demonstration (SDD).

T&E also serves as a decision-making tool for senior leaders in DoD. T&E events are required before a system can undergo a Milestone Review. Figure 12 illustrates the relationship between T&E and the Acquisition Process.

The Test and Evaluation Master Plan (TEMP) is written as a part of the formal Acquisition Strategy pending a Milestone B decision authorizing entry into System

Development & Demonstration (SDD). The TEMP addresses system items to be tested as well as laying out the Integrated Test Program (ITP) Schedule. The TEMP is updated continuously throughout the program and officially at each Acquisition Milestone.

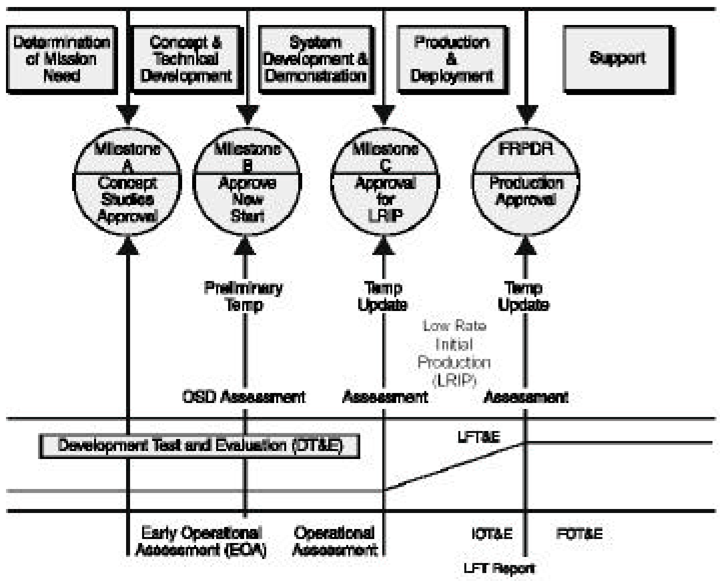


Figure 12. Testing and the Acquisition Process, from (Test and Evaluation Management Guide, 2001).

The TEMP updates include guidance from the MDA on testing areas of interest during the follow-on acquisition phase. Testing areas focus on validating system capabilities and detecting and reporting of “deficiencies that may adversely impact the performance capability or availability/supportability of a system.” (Test and Evaluation Management Guide, 2001, p. 1-4)

In summary, T&E is “the discipline that helps to illuminate risk areas of vulnerability.” (Test and

Evaluation Management Guide, 2001, p. 1-7) A rigorous T&E program can identify and manage program risks in a manner that saves time and money, while also ensuring that the tester provides the user timely and cost effective answers to operational requirements.

2. Cost as an Independent Variable (CAIV)

Cost as an Independent Variable (CAIV) is the process of balancing cost, schedule, performance and risk early in a systems development in order to manage a program to a cost objective.” (Risk Management Guide for DoD Acquisition, 2001, p. 29) CAIV involves a joint PMO-user representative trade-off analysis between system performance and program costs. The underlying premise of CAIV is that “if costs are too great, and there are ways to reduce them, then the user and developer may reduce performance requirements to meet cost objectives.” (Risk Management Guide for DoD Acquisition, 2001, p. 30) Risk assessments are essential in the CAIV trade-off process.

Assessing risk areas and identifying cost drivers provide PMs and user representatives with data that can be used when conducting trade-offs between system performance and cost. The concept of CAIV is that “equal emphasis must be placed on managing cost and schedule risks” as it is on system technical risk. (Risk Management Guide for DoD Acquisition, 2001, p. 30)

3. Earned Value Management (EVM)

The Earned Value Management System (EVMS) is a joint DoD-Industry agreement established in 1995 that details DoD 5000.2-R contractor requirements with respect to the implementation of Earned Value Management (EVM). EVM is a process that, through one hundred percent system

decomposition and definition, evaluates a program's progress in terms of cost and schedule. EVM can be used as an "early warning signal" to a PM to identify risks of overrunning cost or schedule constraints. (Earned Value Project Management, September 2002)

By decomposing a system's requirements and defining the system thoroughly, managers can provide cost estimates per development function and track the program's progress. PMs periodically assess actual costs to date versus projected costs and actual time requirements versus projected time to determine variances. The identification of variance can help identify new or underestimated risk areas and alert the PM to take action to assess and mitigate the cost or schedule risks. Figure 13 illustrates that a program's progress may be evaluated after only 15% completion of the program.

The key to using EVM effectively is an accurate program process definition and decomposition. When used properly, EVM affords a PM visibility on a program's cost and schedule status. The PM can then make necessary changes or perform trade-off studies to meet cost and schedule thresholds. EVM is an effective technique to combat cost and schedule risks.

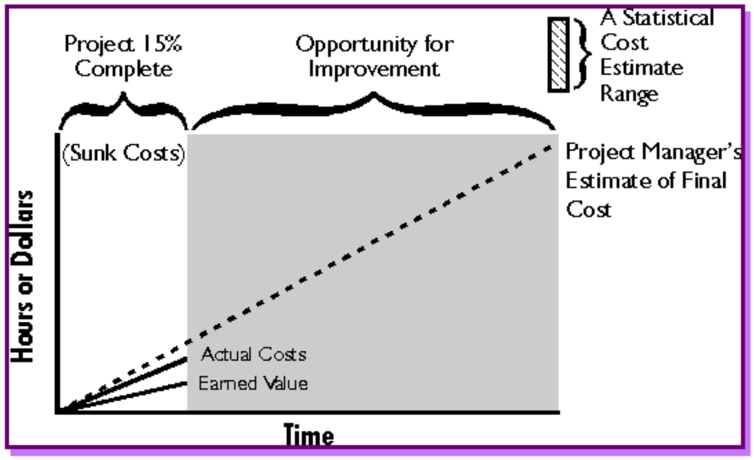


Figure 13. Earned Value Management As a Risk Management Technique, from (Earned Value Project Management, September 2002).

4. Modeling and Simulation

Modeling and simulation (M&S) may be used by a PMO to manage risk throughout the entire life cycle of a system. Models and simulations can "reduce time, resources, and acquisition risk" and may contribute to increasing the system's overall quality and performance. (Risk Management Guide for DoD Acquisition, 2001, p. 27) In managing risk, M&S can assist in the following ways:

- Develop alternate concepts during system design
- Predict performance in support of trade-off studies
- Evaluate system design and support preliminary design reviews
- Predict performance and supplement live tests during system testing
- Examine the military value of the item
- Determine the impact of design changes
- Hone requirements

- Develop life-cycle support requirements and assessments (Risk Management Guide for DoD Acquisition, 2001, p. 27)

The risk management techniques this thesis has addressed are not mutually exclusive. For, example M&S may be used extensively during T&E.

Modeling and Simulation during T&E may be used for "concept evaluation, extrapolation, isolation of design effects, efficiency, representation of complex environments and overcoming inherent limitations in actual testing." (Test and Evaluation Management Guide, 2001, p. 14-8) By performing M&S during T&E, the PM may thoroughly test a system under virtual conditions and environments, which may otherwise be cost-prohibitive. M&S helps to reduce technical risk by discovering design effects on the overall system before physically incorporated into the system. M&S reduces schedule and cost risk by assisting engineers to make the right decisions early based on data gathered during M&S tests. Additionally, models, which prove to be accurate predictors of actual test events may allow the PM to waive further, live tests based on a high degree of confidence in the model's data.

Modeling and Simulation is only as good as the data and variables that are inputs to the model. M&S can be a great risk management tool if adequate time is taken to ensure the accuracy of input data. The DoD 5000.2-R encourages PMs to incorporate M&S activities where applicable to their respective programs because of the potential cost and time reductions as well as enhanced system development and performance validation.

5. Including Risk Management in the Contracting Process

The final risk management technique this thesis addresses is the inclusion of risk management throughout the contracting process. Managing risk through contracting often involves risk transference from either the Government to the contractor or vice versa. "By properly setting the expectations of all players, explicitly agreeing upon the deliverable items produced by the event, and securing sponsorship from project management, a high degree of success is assured." (SEI, 1999, p. 17) The shift from Military Specifications and Standards to Performance based requirements placed increased risk in the hands of the contractor. However, "if a program fails because risk isn't managed well by the contractor, the PM is ultimately responsible." (Defense Acquisition Deskbook (DAD), Top Eleven Ways to Manage Technical Risk, 1998, p. 3-1) Numerous opportunities exist throughout the contracting process that enables the Government to manage system risk. The remainder of this section discusses risk management through the Request for Proposal (RFP) and contract award fee incentives.

a. The Request for Proposal (RFP)

Even before an RFP is released, a PM should conduct a preliminary risk assessment to ensure that "the program to be described in the RFP is executable within technical, schedule and budget constraints." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-1) The RFP should require offerors to address their RMP and initial risk assessment and mitigation plan for moderate to high-risk areas. (DAD, Top Eleven Ways to Manage Technical

Risk, 1998, p. 3-1) The RFP should also stipulate that offerors must make periodic risk assessment reports to the Government. Contractors’ reports serve as input to the PM’s risk monitoring and tracking program. By requiring a risk-based approach, offerors’ proposals should “state how they would plan and schedule [software] activities based upon realistic assessments of technical challenges and risks” so that the Government may evaluate management capabilities.” (GSAM, 2000, p. 6-30) Whether the development risk is hardware, software or a combination of both, the RFP is a vehicle to inject risk management activities into the program. The RFP contains several sections, which allow the Government to directly address risk areas in the solicitation.

Section C, *Description/Specifications/Statement of Work*, includes any descriptions or specifications required in the offeror’s response. (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-2) Example Section C wording that addresses risk is as follows:

> The Offeror shall describe its proposed risk management program. The Offeror shall describe how they intend to identify, assess, mitigate, and monitor potential technical risks. Critical technical risks which may adversely impact cost, schedule, or performance shall be identified along with proposed risk mitigation methods for all risks identified as moderate or high." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-2)

Section C allows the Government to evaluate offerors’ RMPs and compare competing contractors’ responses with respect to risk identification, assessment and handling. The contractor’s detailed Statement of Work

(SOW) submitted in response to the RFP can inform the Government as to the level of contractor requirement understanding. The SOW may also warn PMOs of high-risk acquisition plans on the part of the contractor.

Section L, *Instructions, Conditions, and Notices to Offerors*, provides instructions to the offeror in proposal preparation. The Government may elect to include risk management requirements in Section L as long as the risk items are consistent throughout the RFP. Example Section L language is as follows:

> The Offeror shall discuss past/present performance in the implementation of risk reduction/mitigation efforts similar to those proposed for the reduction of all risks identified as moderate or high." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-2)

Section L ensures that offerors include information pertaining to risk that may enable the Government to evaluate a contractor's technical past performance or ability to manage technical risk.

Section M, *Evaluation Factors for Award*, notifies offerors of "the evaluation factors against which all proposals will be evaluated." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-2) Section M should focus on areas outlined for offerors in Section L so that the Government's instructions for proposal preparation are consistent with the evaluation criteria. Section M should list the relative importance or hierarchy of evaluation criteria such as past performance, risk management, technical performance, cost, schedule, management, etc. The Government is not required to quantify the importance

or ranking of evaluation criteria, but must inform offerors which criteria will be considered most in the source selection process. An example Section M risk management language follows:

> The Government will evaluate the Offeror’s proposed risk management program and plans for identifying, assessing, mitigating, and monitoring risks, as well as proposed plans for mitigating those risks identified as moderate or high." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-3)

Through specific risk management Section L instructions and corresponding Section M evaluation criteria, the Government can ensure that only proposals that demonstrate responsible and capable risk area handling are considered for contract award.

The DoD 5000.2-R states that risk reduction through the use of mature technology will be a significant factor in the Source Selection Process (SSP). The purpose of the SSP and competition in contracting is to “select the contractor whose performance can be expected to meet the Government’s requirements at an affordable price.” (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-4) Several vehicles, including the detailed Statement of Work (SOW), aid the PM in evaluating solicitation respondents.

b. Statement of Objectives (SOO)

The Statement of Objectives (SOO) is a concept that transfers the responsibility for preparing the Statement of Work (SOW) from the Government to the offeror. (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-3) The SOO is the “primary document for translating performance requirements into contractual tasks.” (GSAM,

2000, p. 8-9) The SOO encompasses top-level objectives and allows offerors greater flexibility and creativity in responding with SOWs that are more detailed. SOOs are intended to not limit contractors by imposing restrictive specifications.

Having offerors prepare SOWs is intended to reduce costs and time previously spent by the Government. The SOO may inform offerors of the Government's objective of identifying, assessing, handling and tracking risk areas. Contractors may respond with detailed RMPs or risk assessment methodologies in the SOWs contained in their proposals. If identified in Section M, offerors' risk management methodology contained in the SOW may be used as evaluation criteria during the SSP.

Figure 14 illustrates the RFP preparation process.

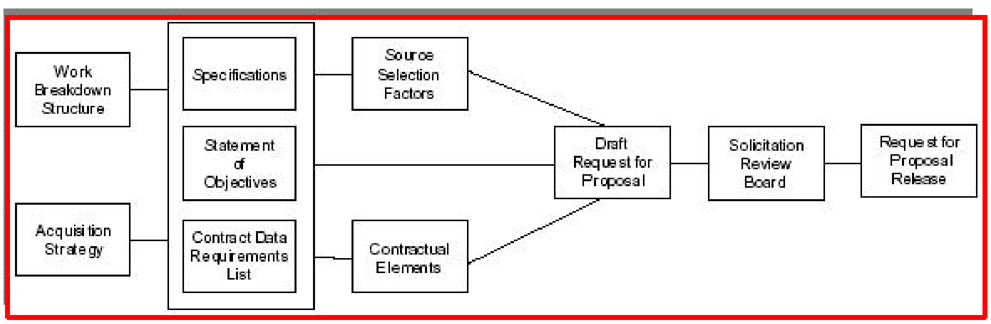


Figure 14. RFP Preparation Process, from (GSAM, 2000).

c. Risk Management Based Award Fees During Contract Administration

The process of selecting a contract type is based on many factors. The contractor's technical ability, urgency of the program or the type and complexity of the

program are all examples of contract type decision criteria. Providing incentives for contractors to identify and handle risks through Contract Award Fees can be a valuable technique for the Government in systems acquisition risk management.

Award Fee determinations may be based on analysis of offerors' SOWs and "identification of critical areas of program risk." (DAD, Top Eleven Ways to Manage Technical Risk, 1998, p. 3-5) Moderate to high-risk areas are generally good candidates for award fees because they encourage the contractor to focus specific attention on areas whose potential impact to the program is highest. Tying award fees to risk areas identified as moderate to high risk ensures both Government and contractor attention and communication. Award fee discussion between the Government and the Prime Contractor should be held regularly. Award fee discussions should be held quarterly or even monthly to ensure continuous performance feedback for the contractor. This process facilitates open and frequent communication between the PMO and the Contractor and ensures that risk management is a continuous process that requires constant attention.

In order to administer an award fee type contract, contractor performance and award fee criteria must be clearly articulated and measurable. Award fee periods are often tied to specific events such as Developmental Test and Evaluation (DT&E) events or Operational Test and Evaluation (OT&E) events where the contractor has an opportunity to demonstrate achieved

technological maturity or system integration. Award fees may be incorporated into several contract types.

A Cost Plus Award Fee (CPAF) type contract is a "cost reimbursable contract that provides for a fee consisting of a base amount fixed at inception of the contract and an award fee amount that the contractor may earn in whole or in part during performance." (Bonneville Purchasing Instructions, 1998, p. 7-7) The program cost estimate is determined during Government-Contractor negotiations. An Award Fee Plan (AFP) is agreed to upon inception of the contract. The AFP lays out award fee periods as well as award criteria.

The Government must provide the Prime Contractor with frequent feedback concerning contractor performance before it can award, reduce or withhold an award fee. This enables the PMO and the contractor to communicate regularly, and openly, concerning the progress of the program and the status of the program risk handling. Including risk management as part of award fee criteria is a method of transferring risk from the Government to the contractor.

E. SUMMARY

This chapter first defined risk and risk management in the DoD environment. Risk is the probability of an event occurring and the likely impact that event has on the outcome of a program. Risk management involves the identification, assessment, mitigation and finally the tracking and documentation of risk areas within a program.

Several categories of risk, or risk areas exist in DoD acquisition. A program's success is based on the system's

ability to achieve desired performance characteristics within cost and schedule constraints. Risk areas, whether technical, management or requirements can adversely affect a program's ability to comply with cost and schedule constraints and still meet expected performance characteristics.

Finally, this chapter discussed risk management techniques commonly used in DoD systems acquisition. It introduced T&E, EVM, M&S, CAIV and the contracting process as areas with potential for managing risks.

III. THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV)

A. INTRODUCTION

This section provides background information on the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV). Subsequent chapters provide analysis of the AAAV program's risk management techniques during the Program Definition and Risk Reduction (PDRR) Acquisition Phase. A Milestone III review is planned for FY 2007.

B. AAAV HISTORY

The Marine Corps has had an amphibian vehicle since 1941. (Lissner and Dees, March 2002) Its presence in the Marine Corps arsenal has personified the Marines' amphibious assault capability. The necessity for fighting effectively in the littorals has continued to validate the requirement. But, by 1992, the currently fielded AAV had surpassed its planned 10-year service life by twenty years.

Three, separate Mission Area Analyses (MAA) were conducted to determine the AAV's mission effectiveness and suitability. The result was the determination that the AAV was deficient in mobility (land and water), firepower, survivability and command and control. (AAAV DRPM, Program Overview, October 2002) The Center for Naval Analyses (CNA) conducted an AOA to examine alternatives for the Marine Corps and its amphibious assault capability. (Lissner and Dees, March 2002)

The CNA presented thirteen different system solutions to the Marine Corps' needs. The alternatives ranged from amphibian, swimming vehicles to Landing Craft, Air Cushion (LCAC) loaded Bradley Fighting Vehicles. Following the

CNA’s AOA, the Marine Corps Combat Development Command (MCCDC) conducted a supplemental analysis in 1995. The analysis yielded a “hands down” decision to pursue a “fast-swimming amphibian.” (Lissner and Dees, March 2002) The criteria for analysis was based on cost, performance, mission effectiveness and total life cycle cost of the system.

Following the 1995 AOA, the AAAV program entered Program Development and Risk Reduction (PDRR). The AAAV reached a Milestone II review in September 2000. A subsequent AOA was conducted following PDRR to determine the validity of the proposed concept and its projected costs (acquisition and life cycle), performance, and mission effectiveness.

Figure 15. The Advanced Amphibious Assault Vehicle (AAAV), from (FAS, Military Analysis Network, October 2002).

The analysis determined that the AAAV was, in fact, the system that the Marine Corps needed to overcome existing operational deficiencies of the AAV. The AAAV passed the Milestone II review in November 2000 and entered the System Development and Demonstration (SDD) phase. The AAAV is currently in SDD as of early 2003. (Lissner and

Dees, March 2002) (AAAV DRPM, Program Overview, October 2002)

The AAAV prime contractor is General Dynamics Amphibious Systems (GDAS). Its subcontractors and respective subsystem are:

- MTU: Engine
- Allison: Transmission and gear boxes
- Honeywell: Water jets
- Ball: Antenna
- CDC: Communications (AAAV DRPM, Program Overview, October 2002)

The SDD contract calls for the production and testing of nine prototypes prior to the Low Rate Initial Production (LRIP) decision. As of October 2002, three prototypes have been tested in varying terrain and under different operational conditions.

Prototype #1 achieved the High Water Speed Key Performance Parameter (KPP) in April 2000 by reaching a maximum waterborne speed of 38 knots. Prototype #2 has conducted significant land mobility testing. The vehicle achieved Troop Carrying and Land Speed KPPs during 2000. The third prototype has undergone extensive land, water and mobility developmental testing including Early Operational Assessment (EOA) in 2001. (AAAV DRPM, Program Overview, October 2002) In the fall of 2002, the AAAV performed shipboard launch, recovery and interoperability testing.

C. AAAV CHARACTERISTICS

The Marine Corps is developing the AAAV in response to noted operational deficiencies in the currently fielded Amphibious Assault Vehicle (AAV). The AAAV's mission is to

“provide high speed transport of embarked Marine Infantry from ships located beyond the horizon to inland objectives.” (AAAV DRPM, Program Overview, October 2002) The AAAV will provide Marine forces with an enhanced capability to conduct ship-to-shore movement and greater mobility and speed once ashore. The AAAV’s range, speed and enhanced survivability will provide commanders with a “Multiple Options/Late Decision Capability.” (AAAV DRPM, Program Overview, October 2000) The following table illustrates AAAV’s improved capability over the existing AAV.

System Function	**AAAV Requirement**	**AAV Capability**
Water Speed	23-29 MPH	6-8 MPH
Cross-country land speed	45 MPH (keep pace with main battle tank)	15-20 MPH
Range on water	65 miles	45 miles
Range on land	300 miles	300 miles
Troop-carrying capacity	18 combat-equipped troops	18 combat-equipped troops
Survivability	(1) 4.5mm round w/out enhanced armor plating	(1) 4.5 mm round with enhanced armor plating
NBC Protection	Overpressure System (crew and embarked personnel)	None
Lethality	Defeat light armored combat vehicle of 2005-2025 time frame day and night on the move	Incapable of defeating light armored combat vehicle with 40mm and .50 cal weaponry

Table 1. AAAV and AAV Capability Comparison, from (Military Analysis Network/AAAV, October 2002 and General Dynamics Land Systems, October 2002).

The enhanced capability the AAAV provides the Navy and the Marine Corps is the ability to conduct Operational Maneuver From the Sea (OMFTS). Littoral regions previously denying maneuver forces of options will become maneuver areas and avenues of approach. The AAAV will extend the Marine Corps' "operational reach." (AAAV DRPM, Program Overview, October 2002)

D. AAAV ACQUISITION AND PROCUREMENT

The AAAV is the only ACAT ID program managed by the Marine Corps. The AAAV program office is unique as the Government and the prime contractor, GDAS, share the same facility in Woodbridge, Virginia.

The Marine Corps will buy one thousand and thirteen (1,013) AAAVs to replace the AAV at a cost of nearly $7.6 Billion. The AAAV's Initial Operating Capability (IOC) is scheduled for 2008 with full fielding of the system beginning in 2012. (Military Analysis Network, 2002, p. 2) Figure 16 depicts the AAAV's program schedule as of October 2002.

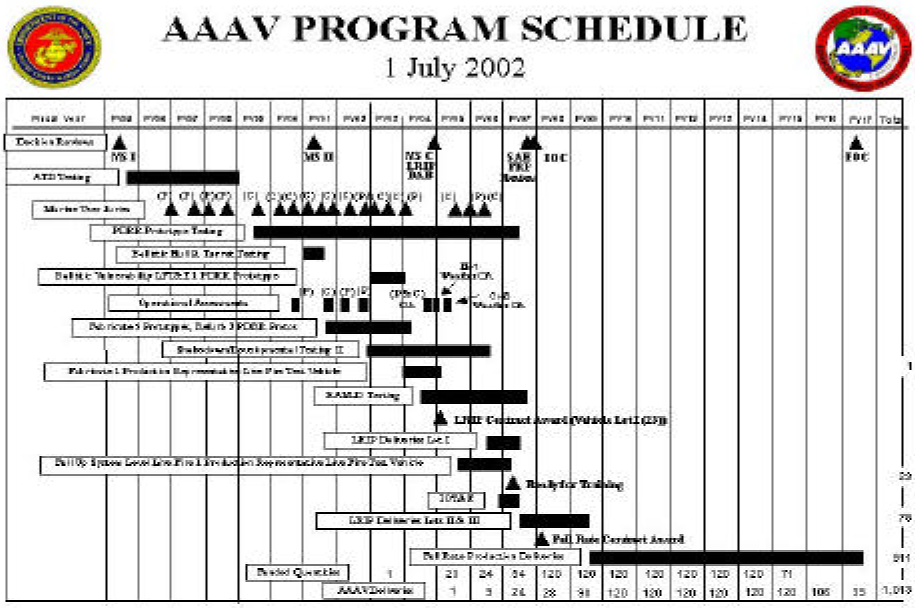


Figure 16. AAAV Program Schedule, from (AAAV Direct Reporting Program Manager (DRPM), October 2002).

IV. THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) RISK MANAGEMENT STRATEGY DURING PROGRAM DEFINITION AND RISK REDUCTION (PDRR)

A. INTRODUCTION

This chapter presents the research methodology this author uses to address the primary and subsidiary research questions. The objective of this chapter is to provide data and information pertaining to the Advanced Amphibious Assault Vehicle's (AAAV) Program Definition and Risk Reduction (PDRR) Phase risk management strategy.

The AAAV Program Management Office (PMO) is employing several risk management (RM) techniques during the System Development and Demonstration (SDD) Acquisition Phase. The next chapter analyzes the lessons learned from the PDRR risk management strategy and how the lessons learned are helping to shape the risk management process during SDD.

B. RESEARCH METHODOLOGY

In order to obtain background information to answer the subsidiary thesis questions, the author conducted a thorough Internet search of Department of Defense (DoD) directives, manuals, guidelines, presentations, handbooks and reports as well as private sector risk management related sites. Additionally, the author conducted a literary search. The sources used in the presentation of the research included newspaper and magazine articles, books, trade journals and other library information resources. The author visited the AAAV Direct Reporting Program Management Office (DRPM) in Woodbridge, VA to conduct interviews with both Government and Prime Contractor program leadership and observe risk management

practices in use during SDD. The latter methodology provided great insight into the current DoD risk management environment.

The majority of AAAV specific, PDRR and SDD Risk Management practices discussed in this thesis came from interviews with AAAV PMO department heads. The author interviewed the System Test Officer, the Senior System Engineer, the Deputy Director of Program Planning and Integration (PP&I) (also the Risk Management Coordinator), the System Chief Information Officer (CIO), and a support contractor charged with consulting on matters of risk. In addition to Government program office personnel, the author interviewed the General Dynamics Amphibious Systems (GDAS) Risk Coordinator (Program Planning Integrating IPT), Assistant Risk Coordinator, and a Quality Assurance Engineer.

C. OBJECTIVE OF RESEARCH

The objective of the research is to collect, decipher and present information and facts that lead to the analysis and discussion of DoD risk management practices. The vehicle for this presentation and analysis of data was a case study of the AAAV. The primary and subsidiary thesis questions are re-stated below:

1. Primary

- How have the lessons learned from the AAAV's Program Definition and Risk Reduction (PDRR) Risk Management Strategy impacted the Program's Risk Management Process during System Development and Demonstration (SDD)?

2. Subsidiary

- What are risk and risk management in Department of Defense (DoD) systems acquisition?

- What techniques can DoD use to manage risk in developmental systems?
- What is the AAAV program?
- What are the lessons learned from the AAAV PDRR Risk Management Strategy?
- What risk management approaches has the AAAV Program Office adopted to manage technical and programmatic risk during SDD?
- What conclusions and recommendations can be drawn from this analysis?

Chapters II and III answered the first three subsidiary questions. This chapter presents data for the purpose of addressing AAAV risk management techniques during PDRR. Subsequent chapters address the remaining questions and conclude by answering the primary research question and providing conclusions and recommendations.

D. AAAV RISK MANAGEMENT TECHNIQUES DURING PROGRAM DEFINITION AND RISK REDUCTION (PDRR)

This section addresses the following risk management techniques employed in the Advanced Amphibious Assault Vehicle (AAAV) Program during PDRR:

- Information Technology Tools
- The Joint Government-General Dynamics Risk Management and Resolution Process
- Contracting
- Government and Prime Contractor Co-Location and the IPPD process
- Test and Evaluation

1. Information Technology Tools

The AAAV Team (Government and General Dynamics Amphibious Systems (GDAS)) utilized robust information technology tools to assist in the management of the program during PDRR. Information sharing within organizational

departments and especially across functional areas was crucial to the program's successful risk management approach. The AAAV Team leveraged many tools and processes. This section discusses the Virtual Design Database (VDD) and the Virtual Integration and Assembly (VINTEGRA) systems.

a. Virtual Design Database (VDD)

The Virtual Design Database (VDD) is a tool that provides users with a virtual, integrated environment. Accessible to both Government and GDAS personnel at any desk or lap top computer, the VDD consists of user-friendly, windows-based electronic documents sorted by Integrated Product Teams (IPT) and aligned by the Work Breakdown Structure (WBS). The VDD "consists of various distributed databases linked together via high speed network connections." (Integrated Digital Environment (IDE), October 2002) IPT areas include Modeling and Simulation, Systems Engineering, Logistics, Mobility Products, Firepower Products, Integration and Assembly, etc. The VDD "provides AAAV IPT members with an on-line, real time, paperless communication system used to logically file and provide access to AAAV program documentation." (IDE, October 2002)

The VDD has the following characteristics:

- Makes data available to all members, USMC, Government, and the subcontractors from a desktop platform
- Provides desktop 3-D Visualization and solid model capability
- Stores data in all electronic formats
- Permits a document author or IPT lead to edit the document

- Integrated e-mail system
- Fully integrated with other PC applications. (IDE, October 2002)

VDD's personal computer interface resembles a Work Breakdown Structure (WBS) format. Drop-down windows allow users to search files by IPTs. Risk Management is facilitated through features, or capabilities, built into the VDD. The features allow efficient sorting of risks. The VDD user is able to select a "Risk" window, which provides access to the entire risk repository containing individual risk forms. VDD also has a "Help" function, which assists unfamiliar users in finding documents or performing functions within VDD easily.

Risk forms contain all information pertaining to particular risks within functional areas of the system. The names of the Risk Owners (to be discussed in the next section), risk assessments, status and mitigation activities are contained on risk forms. Users may review risks and status of mitigation actions as well as generate new risks. An automatic risk notification system alerts other functional areas and program leaders to emerging risks and changes in risk status by generating e-mails containing links to view electronic risk forms. Figures 17, 18, 19 and 20 provide examples of VDD pages.

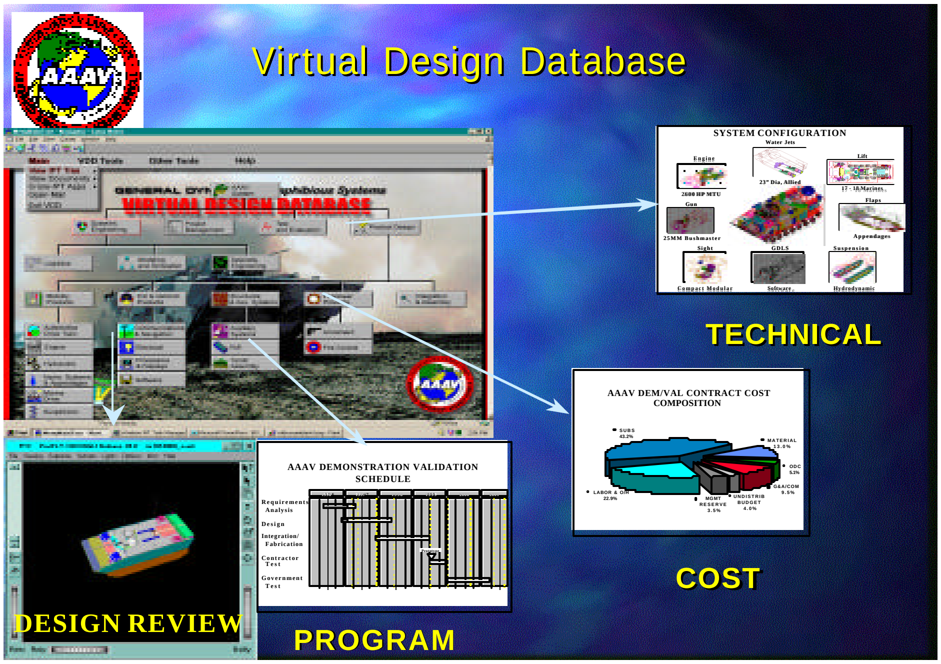


Figure 17. Virtual Design Database (VDD), from (Rob Kepner, EPMC Brief, 2002).

Electronic Risk Forms allow VDD users to perform a myriad of functions. One may enter a new risk into the system, check the status of current risk mitigation actions on risks designated by specific risk numbers, update risk status, etc. Risk form editing is electronically restricted to the designated Risk Owners and others Government and contracting personnel specifically authorized to edit files.

Figures 18, 19 and 20 illustrate the VDD’s access to risk forms and an example of a risk form as it appears on VDD.

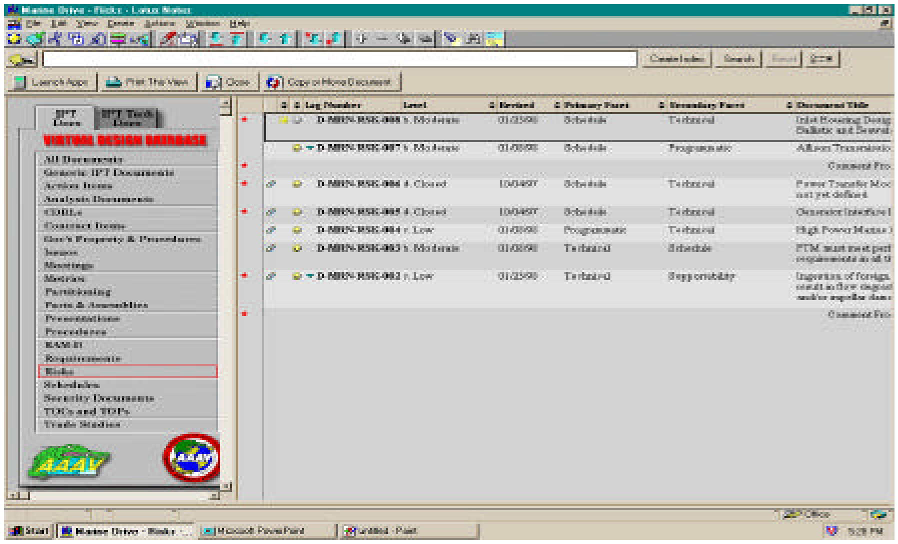


Figure 18. VDD Path to Risk Forms, from (Rob Kepner, EPMC Brief, 2002).

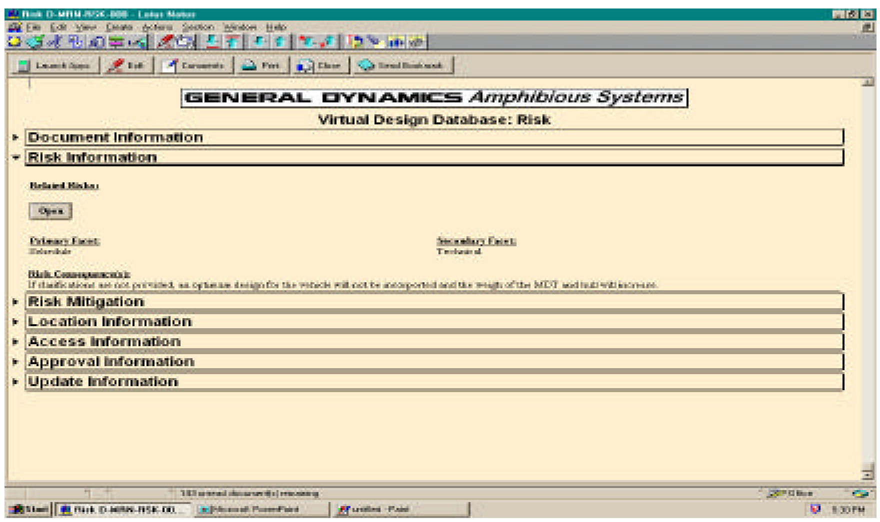


Figure 19. VDD Risk Form from (Rob Kepner, EPMC Brief, 2002).

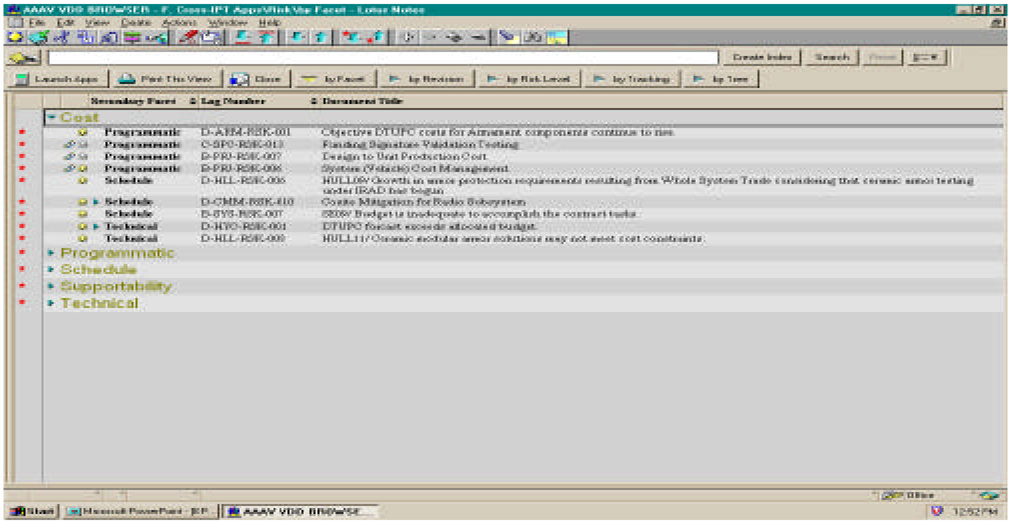


Figure 20. Organization of Risks on VDD, from (Rob Kepner, EPMC Brief, 2002).

b. Virtual Integration and Assembly (VINTEGRA)

The AAAV Virtual Integration and Assembly system (VINTEGRA) is an engineering and manufacturing tool designed to support the continual refinement of system assembly and integration. VINTEGRA is a subset of VDD with many of the same characteristics: accessibility, personal computer interface, automatic e-mail notification, etc. VINTEGRA is intended to capture and facilitate integration and assembly (I&A) and production data. The data leads to the identification of risks associated with I&A and production. VINTEGRA, relying on software called ProProcess, provides shop mechanics with a paperless source of manufacturing and assembly instructions. VINTEGRA is located on AAAV’s Intranet. Shop mechanics use a standard Internet browser, i.e., Internet Explorer, to access VINTEGRA’s drawings and assembly instructions. VINTEGRA may be accessed through computer aided design (CAD)

workstations in the assembly area or on desktop computers anywhere on AAAV's network. "Traditional 'blue-print' style line drawings of the design have been replaced by computer images rendered in the vividness of three dimensions (3-D)." (Defense Modeling and Simulation Office, 1999)

Multiple computer stations surrounding the vehicle hulls undergoing assembly are available to the shop mechanics for reference. VINTEGRA allows shop mechanics to electronically view the proper sequence and method of assembly prior to working on the actual hull. Mechanics control the speed at which they learn the self-paced assembly instruction.

Design imperfections and changes are anticipated during prototype build. VINTEGRA is an interactive system. Mechanics may provide input to engineers if they encounter problems during assembly through an electronic problem reporting system.

VINTEGRA contains an Electronic Problem Resolution System (EPRS) which allows for "real-time capture of assembly problems as they are discovered." (Defense Modeling and Simulation Office, 1999) If a mechanic encounters problems applying assembly instruction, then he or she can mark up the Computer Aided Design (CAD) images to illustrate the exact location and nature of the discrepancy. Because VINTEGRA resides on AAAV's Intranet, the mechanic's corrections or indicated problem areas are immediately brought to the attention of engineering and design teams via electronic dissemination. The teams, in turn, may make real-time changes to the assembly process or

identify potential change requirements for the next design iteration via the configuration management process.

The EPRS form contains the following major subject headings:

- Problem Identification
- Problem Description
- Disposition of Short Term Fix
- Verification of Short Term Fix
- Disposition of Long Term Fix
- Verification of Long Term Fix

Shop mechanics can affect wide dissemination of the EPRS though VINTEGRA.

The AAAV Team won the 1999 Defense Modeling and Simulation Office Award for VINTEGRA.

2. AAAV Team PDRR Risk Management Process

The program’s objective during PDRR is to continue to develop the design and engineering maturity of the system as well as to identify, assess and handle risks. Technical risks tend to attract the majority of attention during PDRR.

The AAAV, Government program office contractually mandated that GDAS institute the program’s risk management process during PDRR. The AAAV Program Manager (PM) approved and oversaw the process. A risk management plan and its implementation by GDAS were second period award fee criteria during PDRR based on the Milestone II contract award. The next section addresses Risk Management through the contracting process in greater detail.

The AAAV Team’s risk management process involved five steps:

- Risk Identification
- Risk Analysis and Prioritization
- Risk Planning
- Risk Tracking
- Risk Control (AAAV Independent Risk Assessment, March 2000)

a. AAAV PDRR Risk Identification

The first step in the AAAV risk management process during PDRR was Risk Identification. Any number of individuals or groups was empowered to identify risks and initiate the management process. Individuals, an IPT or any internal or external AAAV stakeholder could identify new or existing candidate risks. Existing risks could be transferred from one IPT to another depending on the nature of the risk and an IPT’s expertise. New risks were initiated by sending an e-mail or holding a conversation with an IPT lead or the program Risk Management Coordinator (RMC). Existing risks were transferred by one IPT to another or by the Risk Resolution Board (RRB). (GDAS PDRR Risk Primer, April 1998)

The Joint Risk Resolution Board (RRB) was a Joint DRPM/GDAS board designed to analyze and resolve risk issues that required senior DRPM and GDAS attention for resolution.

At the RRB, IPTs presented risk summaries to the board members. Briefs highlighted risk area trends and emerging risks by IPT. The risks were categorized as High,

Moderate or Low-level risks. The AAAV Team categorized risks in the following manner:

- High Risk (Red): Risk is most likely to cause major program impact/disruption. For these risks, a different approach may be required to successfully complete EMD. Priority management attention should be applied.
- Moderate Risk (Yellow): Risk can cause some program impact/disruption. Risk can be resolvable during EMD by proper implementation of mitigation efforts that may involve a different approach. Additional management attention may be needed.
- Low Risk (Green): Risk is at an acceptable level with minimal or no known impact. (Independent Risk Assessment Team (IRAT), 2000)

Each risk was listed by IPT name and by Risk Identification number as seen on the VDD for purpose of reference. (AAAV Program Office Risk Resolution Board Presentation, November 1997)

The RRB had several objectives. First to provide senior leadership with decision support information and ensure cross-functional area communication. Decision criteria included the commitment of additional resources, acceptance of risk, trade offs and mitigation courses of action. Secondly, to provide a forum where decisions were made jointly between GDAS and the Government using the same data. Third, the RRB was the appropriate forum to close out risks nominated for this action. The RRB ensured that the risk management process was performed as intended. Lastly, the RRB intended to reduce risk processing and handling cycle time to facilitate decision-making at the earliest possible opportunity. (Kepner, 2002)

Once a candidate risk was identified, the issue became an IPT or RRB agenda item. Doctrinally, IPTs reviewed candidate risks weekly and existing risks bi-weekly while the RRB reviewed program-level risk continually. The RRB attempted to meet formally on a monthly basis as a “decision-making forum.” (GDAS PDRR Risk Primer, April 1998) The RRB and IPTs reviewed candidate risks to determine one of the following courses of action:

- Control the risk
- Accept the risk
- Reduce the risk
- Transfer the risk (Kepner, 2003)

Determinations on candidate and existing risks were made within five working days of identification and initial discussion. Candidate risks of minor severity were classified as Action Items. IPTs posted Action Items on the AAAV Action Item database found on the VDD. Either the accepting IPT or RRB entered risks on the VDD accompanied by a mitigation plan. Figure 21 illustrates the AAAV, PDRR Risk Management Process with the Risk Identification step highlighted in gray.

When a risk was identified and acceptance assigned, the process required further action. Formal assignment or assumption of Risk Ownership was required for each risk entered into VDD.

The goal was to resolve and close risks at the lowest possible level. When a risk was discovered during PDRR, the Government and GDAS counterparts who uncovered and introduced the risk became “Risk Owners” for that risk. They jointly assumed responsibility for the risk from its

cradle to grave. Risk Owners were identified by name on all risk forms on the VDD to disseminate the overall responsibility for the particular risk. Risk owners were responsible for formally introducing new risks into the VDD through risk forms.

Risk forms indicated the nature and severity of the risk as well as actions to be taken to mitigate the risks.

The purpose of the risk forms was to provide an assessment of current risks and estimate risk resolution requirements and timelines. A critical function of the risk introduction, assessment and mitigation process was to identify resources required to mitigate risks. Risk Forms also contained fields for the entry of “Estimated Recovery Date” of the risk. Time estimates were designed to allow the program office to analyze variances in actual versus estimated risk mitigation times.

While risks were jointly owned between GDAS and the Government, the Government assumed overall responsibility for the risk and its management. Should a situation occur that a risk could not be resolved and closed at the lowest level possible, the risk was elevated through the IPT hierarchy to the Joint Risk Resolution Board (RRB) for resolution.

The next step in the risk management process was Risk Analysis and Prioritization.

Figure 21. AAAV PDRR Risk Management Process: Risk Identification, from (GDAS PDRR Risk Primer, April 1998).

b. AAAV PDRR Risk Analysis and Prioritization

The PDRR risk analysis and prioritization process began upon identification and acceptance of the risk. Within five working days, the owning IPT or RRB was required to initiate a Risk Management Form in VDD. Risk forms in VDD were matched with corresponding Work Breakdown Structure (WBS) numbers. The IPT or RRB assigned Keywords to risk forms. Keywords were "fields which enabled the user to specify unique terminology associated with the risk and aid in the early identification of trends, establishment of triggers and prioritization of constrained resources at the IPT and system level." (GDAS PDRR Risk Primer, April 1998) Keywords were classified as product, practice or process:

- Product Keywords: Names of mechanical, structural, software systems or subsystems unique to AAAV
- Practice Keywords: Categorized into one of six classes: Acquisition, Design, Facilities, Logistics, Manufacturing and producibility or Test and Evaluation
- Process Keywords: Categorized into six classes, which represent "DoD Best Practices": Design, Test, Production, Facilities, Logistics and Management (GDAS PDRR Risk Primer, April 1998)

The AAAV RMC performed regular query-based searches of the database to identify trends in keywords and report the findings to the RRB.

Risk analysis included the Risk Owner preparing a risk statement as a part of the VDD Risk Form. The purpose of the risk statement was to "quantify the cause of the risk and specify which requirement(s) cannot be satisfied if the risk is not mitigated." The risk consequences field

on VDD served to “quantify the effect of degraded operational performance, increased cost, decreased reliability, schedule slip, etc. if the risk was not mitigated.” (GDAS PDRR Risk Primer, April 1998) The PDRR Risk Analysis and Prioritization process is highlighted in Figure 22.

c. AAAV PDRR Risk Planning

The third step in the PDRR risk management process was Risk Planning. Risk planning “includes all management aspects of dealing with risk by choosing a specific course of action for mitigation among the several alternatives available.” (GDAS PDRR Risk Primer, April 1998) Risk planning included risk mitigation and risk tracking VDD entries.

Risk mitigation plans included the following elements:

- Probability of occurrence
- Assessed risk level
- Mitigation plan and history
- Estimated recovery date
- Risk tracking
- Watch list inclusion
- Date closed (GDAS PDRR Risk Primer, April 1998)

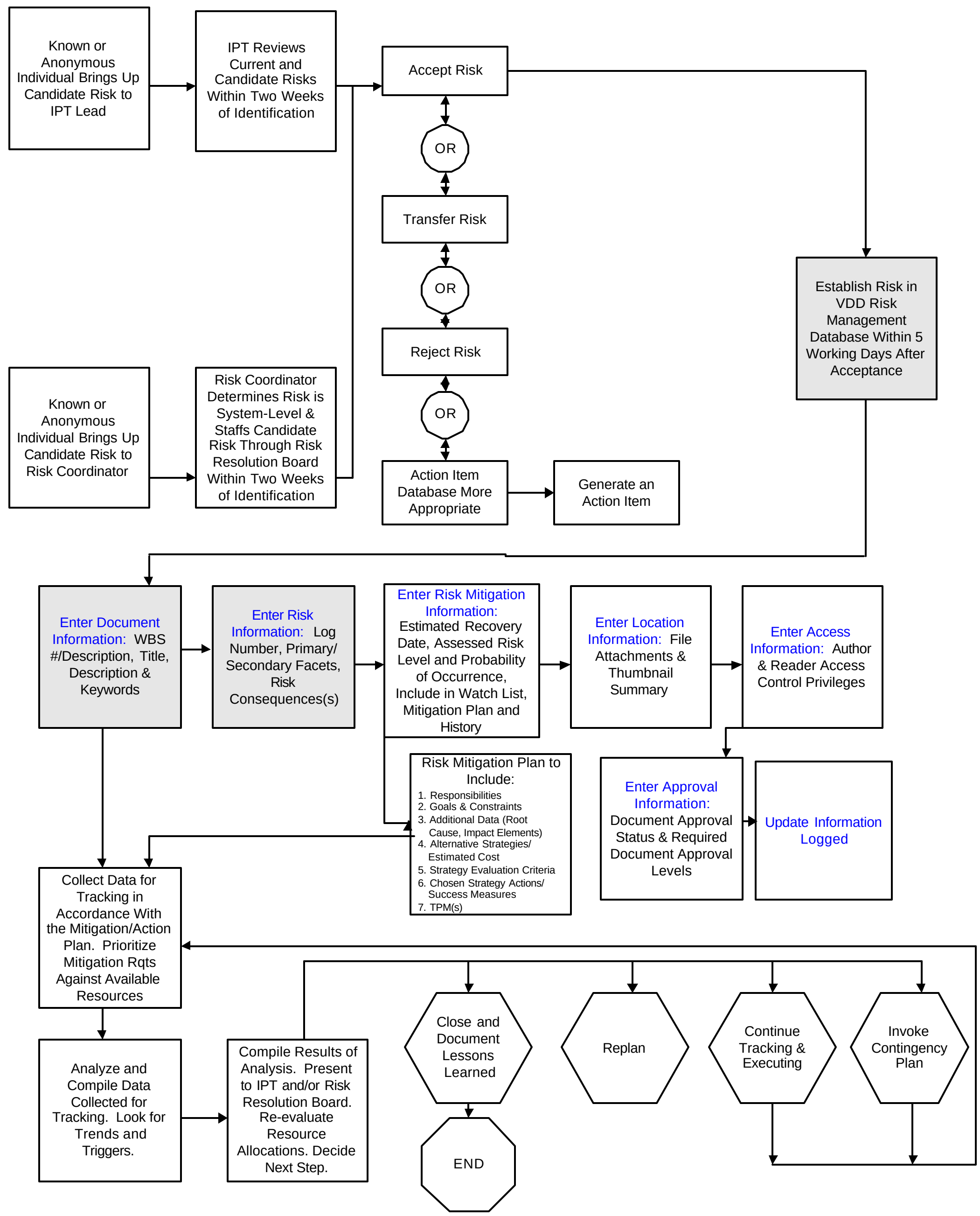


Figure 22. AAAV PDRR Risk Management Process: Risk Analysis and Prioritization, from (GDAS PDRR Risk Primer, April 1998).

The estimated recovery date was a mandatory entry and reflected the IPTs time estimate required to mitigate the risk. When the approving authority determined a risk to be fully mitigated or no longer relevant, then the risk was closed on VDD. The risk tracking entry allowed the risk owner to select between “Off-track” or “Monitor closely” depending on the severity of the risk and the progress of the mitigation efforts. “Off-track” highlighted a risk that was out of tolerance and “monitor closely” brought attention to a risk area that was approaching tolerance limits. The categories allowed managers to prioritize risk areas.

Included in the mitigation plan was the assessed risk level determined by the probability of occurrence and the severity of impact to the program.

Risk mitigation plans included all activities to be conducted and resource estimates in order to mitigate the risk. All mitigation activities needed to be completed prior to the estimated recovery date. The risk’s history was updated each time an IPT revised a risk form. The mitigation history provided traceability. (GDAS PDRR Risk Primer, April 1998)

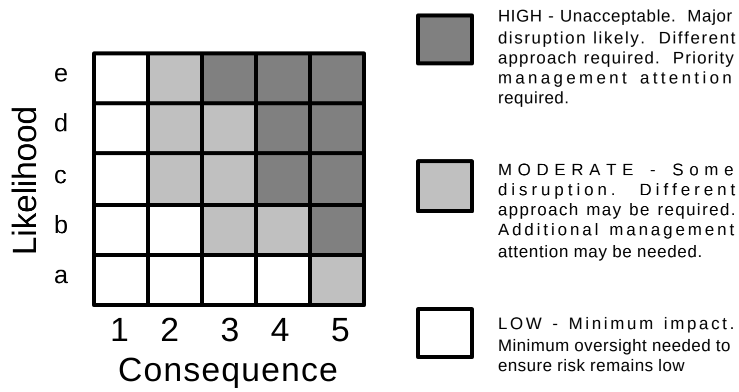
Risks were assessed and categorized into facets of program impact:

- Technical Performance: Risk associated with the enhancements of the design to maximize performance
- Cost: Risks that impact budget
- Schedule: Risks that impacts Milestones and Decision Points

- Programmatic: Risks related to resources (people, equipment, facilities, funding, etc.) and functions of the business
- Supportability: Risks associated with fielding and maintaining the current system (DRPM AAA, Risk Mitigation Planning Guidance for the Risk Owner, 2002)

The probability of the risks' occurrence and the severity of impact on one or more of the above mentioned categories determined the overall risk assessment: Low, Moderate or High. Figure 23 depicts the AAAV PDRR Risk Assessment matrix.

Level	What is the Likelihood the Risk will Happen
a	Remote
b	Unlikely
c	Likely
d	Highly Likely
e	Near Certainty



LEVEL	COST	SCHEDULE	TECHNICAL PERFORMANCE	PROGRAMMATIC	SUPPORTABILITY
1	Minimal or No Impact	Minimal or No Impact	Minimal or No Impact	Minimal or No Impact	Minimal or No Impact
2	<5%	Additional Resources Required	Acceptable with some reduction in Margin	Additional Resource Required	Acceptable with some reduction in Margin
3 some	5 - 7%	Minor Slip in Key Milestones: Not able to meet needed date Required	Acceptable, with some reduction in Margin	Minor Slip in Key Milestones: Not able to meet needed date Required	Acceptable, with reduction in Margin
4	7 - 10%	Major Slip in Key Milestones: Critical Path impacted	Acceptable. No remaining Margin	Major Slip in Key Milestones: Critical Path impacted	Acceptable. No remaining Margin
5	>10%	Can't Achieve Key Team or major program Milestone	Unacceptable.	Can't Achieve Key Team or major program Milestone	Unacceptable.

Figure 23. AAAV PDRR Risk Assessment Matrix, from (GDAS PDRR Risk Primer, April 1998).

d. AAAV PDRR Risk Tracking

The RMC was largely responsible for risk tracking but relied on IPTs to continuously update risk histories and status. The RMC conducted database queries to search for trends in keywords. The RMC compiled the query results and presented them to IPTs and the RRB for analysis. Analysis sometimes included reallocation of resources to address emerging risks or trends. The RMC served as secretariat to the RRB in the risk presentation and analysis process. Figure 24 illustrates the PDRR Risk Tracking process.

e. AAAV PDRR Risk Control

Risk control was the day-to-day management of risks. (GDAS PDRR Risk Primer, April 1998) This phase of the risk management process included the synthesis and decision-making and execution of risk area courses of action. The IPT or RRB responsible for the risk determined one of the following courses of action in consonance with the RMC:

- Close the risk and document lessons learned
- Evaluate the need for re-planning strategies and system-level workarounds
- Invoke alternative mitigation and contingency plans
- Continue to track the risk and execute its mitigation

The authority to make decisions on existing risks was based on the review and approval authority matrix shown in Figure 25.

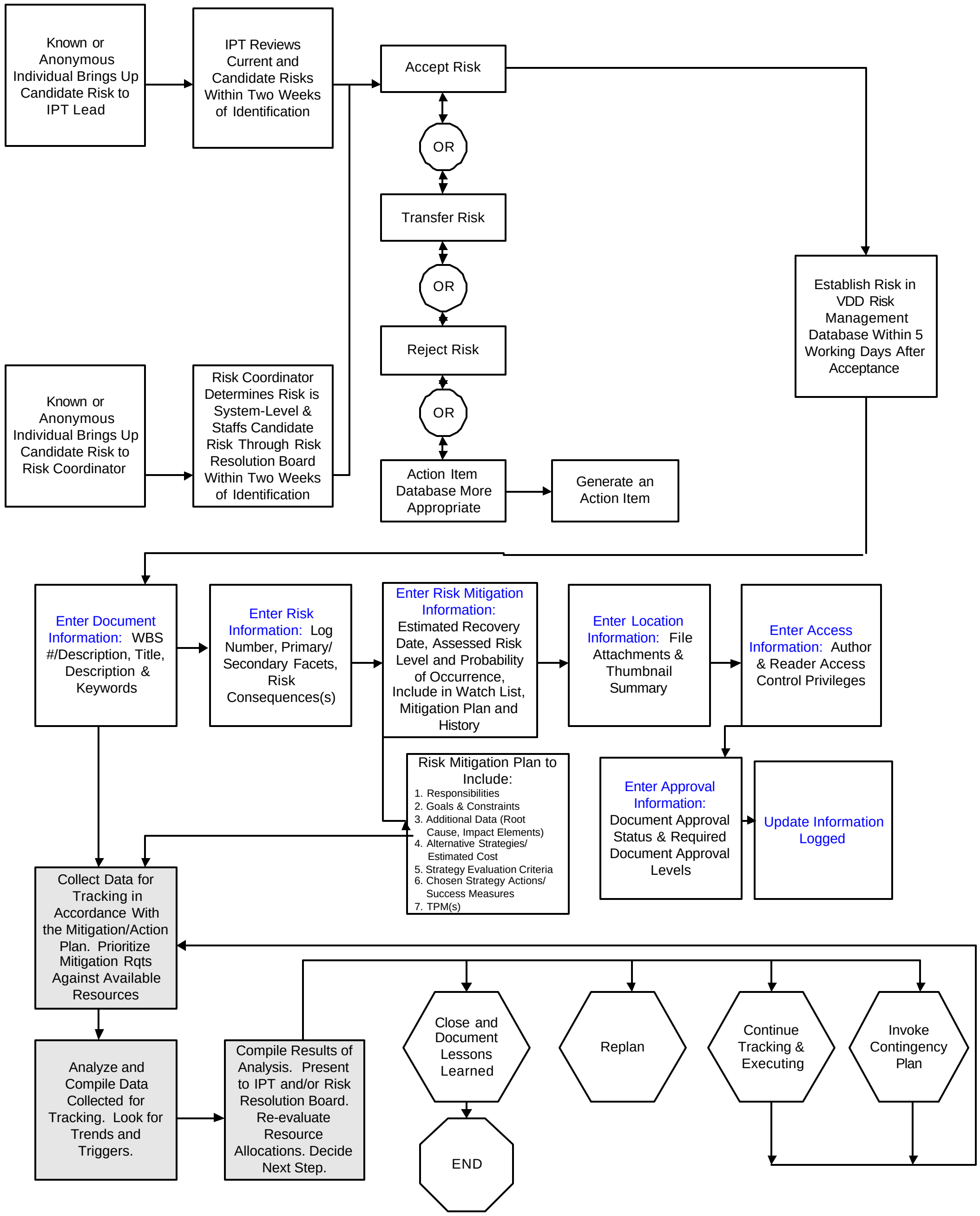


Figure 24. AAAV PDRR Risk Management Process: Risk Tracking, from (GDAS PDRR Risk Primer, April 1998).

The formal PDRR risk management process began on conditions of a Cost Plus Award Fee contract at the beginning of PDRR. GDAS developed the risk management process and the Government approved it. The emphasis of the risk management process was on resolving technical risks during PDRR.

The following section discusses risk management through the contracting process during PDRR.

	Origination Source	Mitigation Plan Review and Approval	Authorized to Closeout Risk
High	A-Level IPT	A-Level IPT	Risk Resolution Board
	B-Level IPT	A-Level IPT	Risk Resolution Board
	C-Level IPT	B-Level IPT	Risk Resolution Board
	D-Level IPT	C-Level IPT	Risk Resolution Board
Moderate	A-Level IPT	A-Level IPT	Risk Resolution Board
	B-Level IPT	A-Level IPT	A-Level IPT
	C-Level IPT	B-Level IPT	B-Level IPT
	D-Level IPT	C-Level IPT	C-Level IPT
Low	A-Level IPT	A-Level IPT	A-Level IPT
	B-Level IPT	B-Level IPT	B-Level IPT
	C-Level IPT	C-Level IPT	C-Level IPT
	D-Level IPT	D-Level IPT	D-Level IPT

Figure 25. AAAV PDRR Risk Review and Approval Authority Matrix, from (GDAS PDRR Risk Primer, April 1998).

3. Risk Management Through the Contracting Process

This thesis introduced in Chapter II several methods to reduce risk through the contracting process. Examples include risk-based Requests For Proposal (RFP), weighting of source selection evaluation criteria, Statement of Objectives (SOO) language and contractual incentives. This thesis presents the AAAV program’s use of contractual awards to incentivize risk management.

Following the Milestone I decision, the Government awarded GDAS a Cost Plus Award Fee (CPAF) contract for the PDRR phase. The PDRR Statement of Work (SOW) required GDAS to have a risk management plan. (Kepner, 2002) The PDRR Second Period Contract Award Fee plan was tied to GDAS' risk management performance. The DRPM AAA established performance criteria to evaluate GDAS' risk management program and supervised the process implementation during PDRR.

GDAS' full award fee amount depended, in part, on its ability to implement an effective risk management program and manage risks during the period.

4. Government and Prime Contractor Co-Location

The AAAV DRPM and GDAS have co-located at the AAAV Technology Center in Woodbridge, VA and the Worth Avenue Technology Annex (WATA) in Dale City, VA three miles south of Woodbridge. Both facilities are two-story buildings with the DRPM AAA occupying the top floor and GDAS the bottom floor. Both facilities have assembly areas where AAAV command mock ups and personnel variant prototypes were assembled during PDRR and continue to be assembled in SDD. The AAAV Team's co-location is truly unique in defense acquisitions. Government and Prime Contractor co-location is intended to enhance communications and reduce program risks inherent with limited cross-functional area interaction. One objective of co-location is to facilitate the Integrated Product and Process Development (IPPD) environment. Communication is crucial to successfully implementing an IPPD process.

a. Integrated Product and Process Development (IPPD)

Chapter II of this thesis introduced Integrated Product and Process Development (IPPD). The DoD defines IPPD as "a management process that integrates all activities from product concept through production/field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives." (Department of the Navy Acquisition, March 2000) IPPD is a systems engineering process that incorporates the use of and interaction between multifunctional teams, or Integrated Product Teams (IPT). This section provides examples of IPT interaction in the IPPD process during PDRR.

b. AAAV Integrated Product Teams (IPT)

The AAAV program uses twenty-eight IPTs with "membership representing every stakeholder in AAAV, from the Marine Users, Government Civilians, Industry (Prime and subcontractors), up through the Office of the Secretary of Defense." (Pollution Prevention: AAAV, October 2002) The IPTs are involved in every aspect of system development and the systems engineering process. The AAAV IPT hierarchy is made up of four levels of IPTs as indicated in Figure 26. Figure 27 depicts the overall AAAV IPT environment.

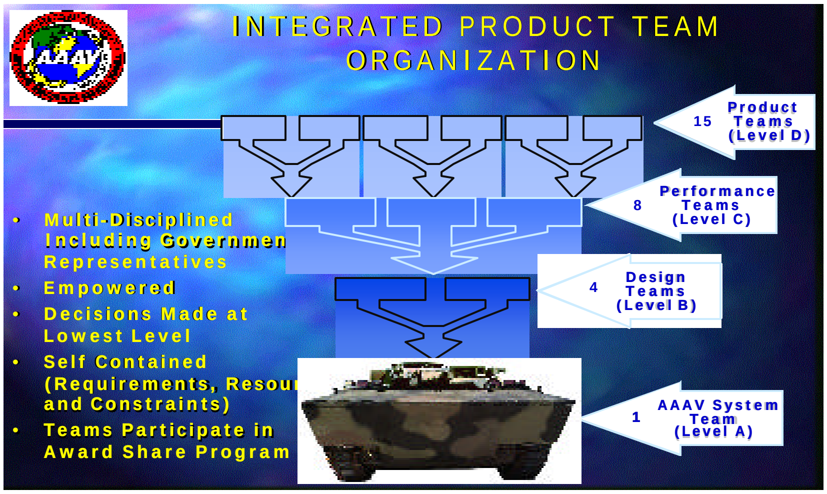


Figure 26. AAAV IPT Hierarchy, from (Rob Kepner, EPMC Brief, 2002).

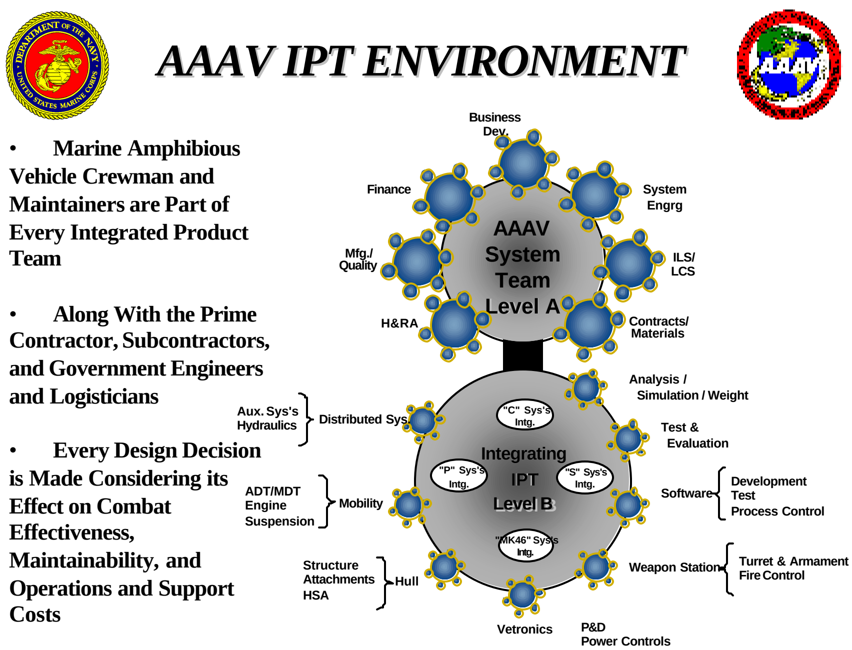


Figure 27. AAAV IPT Environment, from (DRPM AAA IPT Brief, October 2001).

Co-location allows IPTs to work in continual, close proximity with Government, user and contractor counterparts. Numerous risk areas emerge during prototype development and production. The opportunity for IPT members to work together and communicate across functional area lines on a daily, regular basis is critical to capturing and managing risks.

In the area of Environmental Safety and Health (ESH), each IPT has a member who provides expertise and representation for ESH issues. ESH issues play a significant role in the AAAV development. ESH issues represent risk to the program in the form of large disposal costs, potential, adverse environmental impact and safety of use concerns. The following section uses ESH to illustrate IPT interaction in the development of a complex system.

c. AAAV Environmental Safety and Health Program

The National Environmental Protection Act of 1969 (NEPA) mandates Government consideration of environmental impacts imparted by system development, fielding and disposal. In Chapter 5, the DoD 5000.2-R states:

> The PM shall evaluate and manage the selection, use, and disposal of hazardous materials consistent with ESOH regulatory requirements and program cost, schedule and performance goals. (DoD 5000.2-R, April 2002)

The potential environmental impact of an acquisition system can create risks to the program. Risk areas include cost (development, life cycle and disposal), schedule and performance risks. The effective management of ESH issues in a developmental weapon system is critical.

ESH representation in the IPPD process is vital to addressing potential risks for trade off analyses.

Throughout the AAAV's early program definition and continuing through SDD, ESH issues have impacted the system's design and planned production, fielding and disposal. ESH factors can present significant risk to the program should the system fail to meet EPA standards or generate excessive costs attributable to minimizing environmental impact during operation or disposal. The AAAV Team has worked together to ensure the optimal balance exists between the AAAV's performance and System Lifecycle Costs.

AAAV IPTs each included ESH representatives during PDRR. The representatives were tasked with including ESH considerations during the system's design and development trade off processes. The intent was to ensure continual consideration of potential environmental risk impacts to the program throughout the design and prototype manufacturing process.

5. Test and Evaluation (T&E)

During PDRR, the AAAV program office produced three, fully functional prototypes for Developmental Testing (DT) and limited Operational Testing (OT): P1, P2 and P3.

The DRPM AAA conducted extensive DT during PDRR. P2 conducted 4854 miles of land mobility testing: equivalent to nine vehicle years. (DRPM AAA, November 2002). P2 was also used in an Early Operational Assessment (EOA).

An EOA is a type of test "conducted prior to, or in support of prototype testing." (Test and Evaluation Management Guide, November 2001) A combination of AAAV PMO

Marines and 5^{th} to 95^{th} percentile users manned the vehicle during the assessment held in 29 Palms, California in October 2001. The purpose of the EOA was to identify necessary design and configuration changes to the vehicle. The PMO also conducted a gunnery EOA to assess the AAAV's weapon and fire control systems. The EOA enabled the AAAV program to solicit feedback on the system from users at an early stage in the system's development and testing.

P1 and P3 were used primarily for water mobility testing. P3 also participated in weapon station and land mobility test events.

P1 and P3 testing included vehicle transition from water to dry land and vice versa. The prototypes were tested in the high water mobility mode to assess the vehicle's ability to achieve threshold high water speed requirements. The program office conducted informal user juries with the five Marines who performed as DT vehicle crews. The user juries were encouraged to provide continuous feedback to system design engineers throughout testing.

In addition to land and water mobility testing, the AAAV prototypes underwent communication testing (with use of a vehicle mock-up), firepower testing, survivability testing, habitability testing and lifecycle support testing.

Extensive survivability testing included mock-up and prototype test activities to evaluate the system's armor protection and crew survivability. In addition, the PMO placed significant effort in developing and testing an on-

board automatic fire suppression system to increase crew survivability.

Life cycle support testing consisted of logistics demonstrations, maintainability demonstration, mean time to repair (MTTR) demonstration, interactive electronic technical manual validation (IETM) and human factors engineering testing. (DRPM AAA, November 2002)

Figure 28. AAAV Survivability Testing, from (AAAV Developmental Test Brief, November 2002).

E. SUMMARY

During PDRR the AAAV Team worked to identify, assess, mitigate and track technical and programmatic risks. The AAAV Team employed several tools and techniques to manage risk.

General Dynamics Amphibious Systems (GDAS) developed information technology tools to assist in the risk management process during PDRR. The Virtual Design

Database (VDD) was an Intranet tool designed to facilitate communication within and across both Government and contractor functional lines. VDD contained a “Risk” section, which enabled IPT members to initiate, track, update, and disseminate risk items throughout the AAAV program office.

Virtual Integration and Assembly (VINTEGRA) is an engineering and manufacturing tool that provides shop mechanics with 3-D views of system assembly instructions and processes. VINTEGRA has an Electronic Problem Reporting System (EPRS) that allows shop mechanics to provide feedback to system designers and engineers on the assembly process and component design. VINTEGRA provides real-time updates to technical data packages (TDP) shared by GDAS and the DRPM AAA.

The AAAV Team encouraged system risk input at all levels. Individuals who identified risks became “Risk Owners”. Government and contractor counterparts shared risk ownership.

Risk Owners could initiate, edit and communicate all subsequent inputs or changes to risk areas Online through the use of Risk Forms found on the VDD.

Risks are ideally resolved at the lowest possible level in the IPT hierarchy. Those risks deemed significant program risks or those incapable of resolution at lower IPT levels were elevated to a Joint Risk Resolution Board (RRB). The Government and GDAS leadership comprised the RRB. The purpose of the RRB was to provide the program leadership with decision support information and clearly

communicate risks across functional lines at the Integrating IPT level.

The PDRR contract was a Cost Plus Award Fee (CPAF) type. The award fee assessment included the evaluation of GDAS' risk management plan and its implementation. The Government used award fees as an incentive for the Prime Contractor to proactively manage risks.

The AAAV Team is co-located in Woodbridge, Virginia in the AAAV Technology Center and the Worth Avenue Technology Annex; the facilities are approximately three miles apart. The DRPM AAA members and GDAS employees work in the same buildings. The principal purpose of co-location is to encourage and facilitate continual communication between Government and contractor personnel and across functional lines. Co-location is consistent with the principles of the systems engineering and IPPD processes.

Co-location enables IPTs to meet regularly without significant travel requirements or disruption of other responsibilities in the program offices. This thesis illustrates the program use of the IPPD process through a case study involving environmental safety and occupational health issues.

Three AAAV prototypes underwent extensive developmental and early operational testing during PDRR. The purpose of the PDRR test plan was to identify performance risk areas and solicit user input. The PDRR test plan included logistics and life cycle testing.

The next chapter provides analysis of the PDRR risk management plan. This thesis discusses lessons learned

from the PDRR phase and analyzes how those lessons learned have helped shape the AAAV risk management strategy during SDD.

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V. ANALYSIS OF THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) RISK MANAGEMENT PROCESS DURING PROGRAM DEFINITION AND RISK REDUCTION (PDRR)

A. INTRODUCTION

This chapter analyzes data presented in the previous chapter. In Chapter IV, this thesis presented elements of the Advanced Amphibious Assault Vehicle (AAAV) risk management program during the Program Definition and Risk Reduction (PDRR) acquisition phase. The data was categorized into five areas of research:

- AAAV Information Technology Tools
- The Joint Government-General Dynamics Risk Management and Resolution Process
- Managing Risk Through the contracting process
- Government and Prime Contractor Co-location and the IPPD process
- Test and Evaluation (T&E)

B. RESEARCH METHODOLOGY

This author's research methodology involved extensive Internet and literary searches. There are abundant resources available to research the Department of Defense (DoD) risk management environment and practices. However, with the cancellation of the DoD 5000 Series of documents, further research is necessary in the future to ascertain the revised risk management directives and methodologies used in DoD acquisitions. As this thesis is a case study of a developmental program that began under the DoD 5000.1 and DoD 5000.2-R directives, the associated DoD risk management practices are evident throughout the program's history from PDRR through System Development and Demonstration (SDD). What will be of interest is how the

revised acquisition guidelines impact current and future risk management processes in developmental weapon systems including the Advanced Amphibious Assault Vehicle (AAAV).

This author visited the AAAV program office in Northern Virginia. The ability to observe program operating procedures and interview both Government and contractor personnel was invaluable to this thesis.

C. OBJECTIVE OF RESEARCH

The purpose of this chapter is to analyze the risk management techniques the AAAV Team used during PDRR. Based on the analysis of the PDRR risk management process and techniques, this thesis intends to tie correlations between lessons learned from PDRR to the risk management process currently being used in SDD.

D. ANALYSIS OF RISK MANAGEMENT TECHNIQUES USED DURING PROGRAM DEFINITION AND RISK REDUCTION (PDRR)

The purpose of this section is to analyze the risk management techniques and processes the AAAV Team used during PDRR. This chapter addresses risk management process changes from PDRR to SDD, the system's current acquisition phase. This chapter analyzes data in the following sequence:

- AAAV Information Technology Tools
- The Joint Government-General Dynamics Risk Management and Resolution Process
- Managing Risk Through the Contracting Process
- Government and Prime Contractor Co-location and the IPPD Process
- Test and Evaluation

1. Information Technology Tools

The AAAV Team's use of information technology (IT) tools during PDRR was invaluable. The joint Government-General Dynamics Amphibious Systems (GDAS) IPPD process was enhanced by the use of both the Virtual Design Database (VDD) and the Virtual Integration and Assembly (VINTEGRA). Recognizing the "communication multiplier" effect of tools like VDD, AAAV is developing a similar, upgraded application. (Kepner, 2002) The following sections discuss the lessons learned and SDD perspectives of both VDD and VINTEGRA.

a. Analysis of the Virtual Design Database

The Virtual Design Database (VDD) provided the AAAV program office with a top-level view of the overall program. In particular, VDD provided a central repository for risk forms containing identification, assessment, mitigation planning and flexible documentation. VDD's organization matched the system's Work Breakdown Structure (WBS) from which the IPT organization was aligned. VDD was a logical, Lotus Notes-based application that facilitated involvement at all levels in the risk management process.

VDD's built-in help function facilitated risk data entry. Significant emphasis was placed on making VDD user-friendly in order to avoid discouraging IPT members from using the system. VDD's automatic, interactive risk notification system ensured widest dissemination of risk forms and updates throughout the program offices. The automatic notification system was interactive because it required the determination of candidate risks to be made within five days of identification and electronic notification. IPT leads and program leadership were

involved in risk identification, mitigation plans and tracking from the outset of new risks. VDD helped to reduce the occurrence of poor communication within the program office. VDD applications helped to implement the risk management process.

Risks identified, assessed and entered into the VDD were required to contain mitigation plans. The plans included estimated recovery dates and anticipated resources required to mitigate the risk. Mitigation activities were tracked through the VDD as described earlier in this and the previous chapter.

To manage technical risks, the AAAV Team conducted extensive Modeling and Simulation (M&S), Cost as an Independent Variable (CAIV) trade-off analyses, and advanced technology demonstrators (ATD). The purpose of the ATDs was to evaluate the military utility and effectiveness of advanced technology concepts and to prepare to transition capabilities into the acquisition cycle.

The AAAV PMO used ATDs and M&S extensively during PDRR to manage technical risks and perform trade off studies. The AAAV PMO built a 4/5-size hydrodynamic test rig to prove the planning craft technology as well as an automotive test rig to prove the vehicle’s retractable suspension and lightweight track technology. (Kepner, 2003) In M&S, the PMO used the NATO Reference Mobility Model (NRMM) using AAAV vehicle characteristic inputs (approach angle, departure angle, weight, height, etc.) to simulate vehicle terrain handling and mobility characteristics. Both ATD and M&S activities were intended to greatly

mitigate technical risks at the outset of PDRR by identifying key system characteristics and identifying potential risk areas.

The result of the risk management efforts during PDRR was the production of three fully functional AAAV prototypes. (Kepner, EPMC Brief) VDD was a way of communicating the results of trade-off analyses and other risk mitigation activities.

The VDD was an effective risk communication tool during PDRR. One important characteristic of VDD was the "write once, read many" quality of the application. (Kepner, 2003) "Write once, read man" illustrates VDD's utility as a communications multiplier within the program office. However, GDAS and AAAV Government personnel feel that the system was out-dated and incapable of being effective during SDD. Some program office personnel considered VDD a risk repository that eventually became saturated with data. (Rose, 2002) VDD lacked functional aspects that the program office feels are important during SDD: trend analysis, metric reporting capabilities, and analysis of variance (ANOVA). GDAS felt that VDD risk mitigation plans were stand-alone documents, not fully integrated into the overall program management. The Independent Risk Assessment conducted prior to Milestone II found that VDD was "more of a status report of activities or a list of planned events or meetings" rather than useful mitigation plans. (IRAT, September 2000)

Subcontractors had limited access to VDD. High and moderate risks owned by sub-contractors were

incorporated into VDD. As the AAAV program grew, the need for an expanded system became evident.

In SDD, the AAAV is developing an upgraded application that will replace VDD. The new system, Life Cycle Information System (LCIS), is a web-based application that will allow all Government, Prime and Sub-contractors to access the database from AAAV desktop machines as well as remotely through standard Internet browsers. Another impetus behind the development of LCIS is that the AAAV program has been designated as a Program Management Office of Life Cycle Support (PMOLCS). A PMOLCS designation directs that a PMO maintain responsibility for the system from “cradle to grave.” (Kepner, 2003) LCIS will be better equipped to support this function than was VDD.

LCIS training is scheduled to begin in January 2003. The AAAV Team recognizes the importance of incorporating sub-contractors in the risk management process. AAAV intends to fully train sub-contractors on LCIS and include them in the risk management process by offering this web-based application.

GDAS, through their sub-contractor, Computer Systems Corporation (CSC), is developing LCIS to become a “customized document management system.” (Rose, 2002) LCIS will be capable of conducting ANOVA when analyzing mitigation efforts. LCIS will track projected resource outlays versus predicted outlays; determine the effectiveness of the mitigation plan; and alert program leadership to cost, schedule or programmatic impacts. The AAAV Government team feels that LCIS will be able to

support a life cycle support system that emphasizes program-wide impact of risks.

b. Analysis of Virtual Integration and Assembly (VINTEGRA)

The Defense Modeling and Simulation Office awarded the AAAV Program Management Office (PMO) the 1999 award for excellence in Modeling and Simulation. The benefits gained from VINTEGRA during PDRR are already evident in SDD and anticipated during subsequent production activities.

Refining engineering assembly knowledge benefited PDRR efforts by accomplishing "scope commonly done during Engineering and Manufacturing Development (E&MD) (now SDD) phase." (Defense Modeling and Simulation Office, 1999) Furthermore, the "information captured using VINTEGRA in PDRR, significant data for production line analyses will be collected before the conclusion of PDRR." (Defense Modeling and Simulation Office, 1999) The data collected during prototype builds in PDRR will be applied to SDD vehicles.

The SDD prototype vehicle assembly process benefited from the use of VINTEGRA during PDRR. The assembly process has been refined and the Government and contractor have identified and corrected many manufacturing and produceability issues during the first three, PDRR prototype builds. Both the Government PMO and GDAS consider production to be low risk partly due to VINTEGRA and the prototype assembly process.

The process sheets in VINTEGRA are continually refined and updated. In essence, the manufacturing process during PDRR and for prototype builds was a prototype of the

eventual manufacturing process. The goal was to reduce risks associated with system manufacturability, such as schedule and cost risks.

Shop mechanics' familiarity with vehicle process sheets and the Internet-based browser and hyperlinks in VINTEGRA is expected to result in a learning curve effect. The benefits from the learning curve will be realized in the form of reduced vehicle build-time, or cycle time, and improved quality in manufacturing. The result will be reduced risk of missing system delivery dates and costly re-work of the system at the end of the production process.

Additionally, the re-use of VINTEGRA's three dimensional drawings and process sheets are expected to avoid costs normally incurred in the development of Interactive Electronic Technical Manuals (IETM). The electronic process sheet drawings have been validated and will be used in the IETM development.

Electronic tools like VINTEGRA show potential for "shortening acquisition lead time and meeting war fighter needs faster, better, and cheaper, with the consequence of lower risk to the program." (Defense Modeling and Simulation Office, 1999) This will enable the Marine Corps to field a higher quality system to the war fighter at a lower design to unit production cost (DTUPC). VINTEGRA has enabled the AAAV's Integrated Product and Process Development (IPPD) to anticipate system changes early in the vehicle's prototype design and manufacture. Implementation of necessary design changes early in the system's development will reduce technical and integration

risks and the risk of increasing DTUPC and delayed system delivery.

Realizing the success earned through the use of information technology (IT) tools during PDRR as well as the need to expand existing capabilities, the AAAV program continues to innovate acquisitions through its creative use of IT applications during SDD.

The Department of the Navy (DoN) Electronic Business (eBusiness) Operations Office sponsored the DRPM AAA office to conduct a pilot program to pursue expanding VINTEGRA and, eventually, LCIS connectivity to remote sites. Sites such as remote test facilities did not previously have access to the information and communication capabilities captured by the AAAV's IT applications during PDRR. AAAV's creative IT innovations will continue to expand benefits in managing program risks during SDD by creating "virtual, integrated environments." (Hepler, 2002)

2. Analysis of AAAV PDRR Risk Management Process

As discussed in the previous section, the AAAV PDRR risk management process relied heavily on the VDD to initiate, assess, communicate and track risks. However, VDD was only a tool to help execute the formal risk management process.

The PDRR risk management process involved five steps:

- Risk Identification
- Risk Analysis and Prioritization
- Risk Planning
- Risk Tracking
- Risk Control

This section analyzes the PDRR risk management process and discusses the lessons learned. The lessons learned from the PDRR risk management process helped to shape the proposed Government/GDAS risk management processes for SDD. At the time this thesis is being written, the formal SDD process is not yet implemented. This thesis briefly discusses the interim risk management process. The impetus of the risk management process is transitioning from technical to system-level integration risks. However, the relevance of this analysis is in the discussion of what worked and what did not work during PDRR and how those lessons learned are put to use during SDD.

a. AAAV PDRR Risk Management Process

The AAAV PDRR risk management process was effective. The primary goal was to identify, assess, and mitigate technical risk areas to support decision-making and design trade-offs. By focusing on technical risk management, the AAAV program was able to conduct CAIV analyses and perform modeling and simulation activities to determine the most effective design characteristics with respect to cost, schedule and performance. Key elements to the PDRR risk management process were ease of implementation via the VDD and effective communications of the process.

The AAAV Team communicated the formal risk management plan through the IPT levels via a Risk Primer. The Risk Primer provided risk management process instructions intended for use as a desktop reference for risk management. The Risk Primer was an easy to use, procedural nineteen-page document. The intent was to introduce and include risk management in the normal

operations of the program office, not to bog IPT members down in formal methodology details. The primer provided instructions on identification, analysis, planning, tracking and control processes and use of the VDD.

The lesson learned was that a simplified risk management methodology education process is crucial to the successful implementation of a risk management plan. The process and education, or training, must extend to the subcontractors as well as the prime contractor and Government personnel. As the program transitions from development to production preparation, it becomes especially important to maintain a formal risk management process with all program stakeholders. Once the SDD process is formalized, the program intends to incorporate a risk primer as part of the process training.

The methodology the AAAV Team used to manage risks during PDRR was sound. Because the majority of risks during PDRR were technical risks, the DRPM AAA RMC was a systems engineer with a part-time risk focus. The RMC was well equipped to coordinate and manage risk areas because of the integral role that he played during the acquisition phase. As the AAAV program transitioned from PDRR to SDD, the risk management coordination also transitioned.

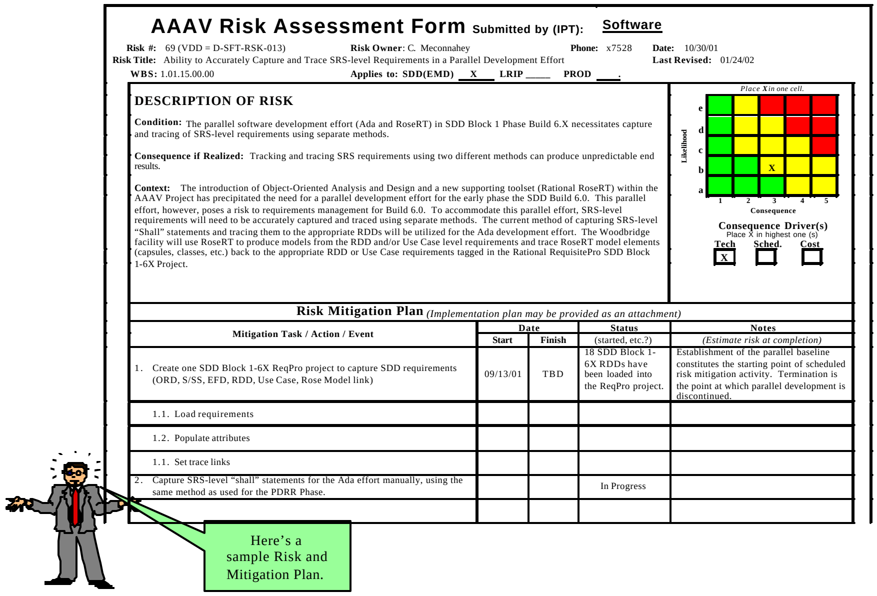
Additionally, shortfalls and limitations of the VDD are currently being addressed through the development of LCIS. Currently, the AAAV Team uses shared drives available on all desktop computers connected to the program’s Intranet. IPTs use standardized risk forms to initiate the risk management process. The risk forms used in SDD differ from those used in PDRR.

The SDD risk forms are Microsoft Word documents that capture the risk assessment and other pertinent information, as a placeholder pending the full functionality of LCIS. Figure 30 illustrates the current risk form the AAAV Team uses during SDD. Risk forms contain information on the following:

- Risk Ownership
- Risk Title and description
- Risk Assessment
- Risk Mitigation Plan and status

The current risk forms and their location on the DRPM AAA/GDAS shared drives are temporary while the program migrates from VDD to LCIS. Risk owners are responsible for updating risk mitigation activities and assessments just as in PDRR. DRPM AAA and GDAS personnel may access and review all risk forms contained on the shared drives. Figure 29 depicts an example AAAV SDD risk assessment form.

While the AAAV program's PDRR risk management process resulted in the successful deployment of three prototypes used in testing and production refinement, the PMO now benefits from lessons learned during PDRR.



AAAV Risk Assessment Form Submitted by (IPT): Software

Risk #: 69 (VDD = D-SFT-RSK-013) **Risk Owner**: C. Meconnahey **Phone:** x7528 **Date:** 10/30/01
Risk Title: Ability to Accurately Capture and Trace SRS-level Requirements in a Parallel Development Effort **Last Revised:** 01/24/02
WBS: 1.01.15.00.00 **Applies to: SDD(EMD)** X **LRIP** _____ **PROD** ____.

DESCRIPTION OF RISK

Condition: The parallel software development effort (Ada and RoseRT) in SDD Block 1 Phase Build 6.X necessitates capture and tracing of SRS-level requirements using separate methods.

Consequence if Realized: Tracking and tracing SRS requirements using two different methods can produce unpredictable end results.

Context: The introduction of Object-Oriented Analysis and Design and a new supporting toolset (Rational RoseRT) within the AAAV Project has precipitated the need for a parallel development effort for the early phase the SDD Build 6.0. This parallel effort, however, poses a risk to requirements management for Build 6.0. To accommodate this parallel effort, SRS-level requirements will need to be accurately captured and traced using separate methods. The current method of capturing SRS-level "Shall" statements and tracing them to the appropriate RDDs will be utilized for the Ada development effort. The Woodbridge facility will use RoseRT to produce models from the RDD and/or Use Case level requirements and trace RoseRT model elements (capsules, classes, etc.) back to the appropriate RDD or Use Case requirements tagged in the Rational RequisitePro SDD Block 1-6X Project.

Risk Mitigation Plan *(Implementation plan may be provided as an attachment)*

Mitigation Task / Action / Event	Date		Status	Notes
	Start	Finish	(started, etc.?)	*(Estimate risk at completion)*
1. Create one SDD Block 1-6X ReqPro project to capture SDD requirements (ORD, S/SS, EFD, RDD, Use Case, Rose Model link)	09/13/01	TBD	18 SDD Block 1-6X RDDs have been loaded into the ReqPro project.	Establishment of the parallel baseline constitutes the starting point of scheduled risk mitigation activity. Termination is the point at which parallel development is discontinued.
1.1. Load requirements				
1.2. Populate attributes				
1.1. Set trace links				
2. Capture SRS-level "shall" statements for the Ada effort manually, using the same method as used for the PDRR Phase.			In Progress	

Figure 29. AAAV SDD Risk Assessment Form, from (AAAV Risk Mitigation Planning Guidance for the Risk Owner, November 2002).

Those lessons learned are already helping shape and improve the risk management process during SDD. The next section discusses several lessons learned from the PDRR risk management process and introduces what practices the program has adopted as a result of the lessons learned.

b. AAAV SDD Risk Management Process

The goal of an effective risk management process during SDD is to deliver:

- Fewer unexpected costs
- Better cost control
- Improved adherence to program schedule
- Enhanced vehicle performance (Risk Coalition Team Brief, June 2002)

The current, SDD contract requires GDAS to develop for the Government's approval a formal risk management process. The process used during PDRR focused primarily on technical and system-level risks. When consistently implemented, the PDRR risk management process effectively helped the AAAV Team to manage technical risks. Similar to the PDRR phase, the GDAS SDD risk management plan will focus mainly on technical and system-level risks: areas that are within the scope of their contractual effort.

However, the DRPM AAA recognized that Government-specific risks exist in SDD that are not adequately addressed or managed through a risk management process developed and implemented by the Contractor like that used in PDRR. The types of risks in SDD are not the same types of risks encountered during PDRR. There are more programmatic risks, which are not within the scope of GDAS' effort. Accordingly, the DRPM as well as the GDAS risk management processes needed to adapt to the program conditions.

As a result, the Government is taking a more active leadership role during SDD to manage Government-specific risks separately from system-level, technical or developmental Contractor risks. DRPM AAA is modifying their risk management plan to enhance the focus on Government-specific risks such as funding, testing and life cycle considerations: those risks outside GDAS' "sphere of influence." (Risk Coalition Team Brief, June 2002) Meanwhile, GDAS is contractually obligated to develop and implement a risk management process for Government approval

and oversight through production. The portion of the Government's plan for technical risks will leverage off of GDAS' plan since both the Government and GDAS will actively manage the technical risks throughout the SDD phase. GDAS' risk management is, again, embedded in contract award fee criteria during SDD.

A lesson learned from PDRR is that risk management is a significant, continuous effort that requires "motivated personnel coordinating risk." (Kepner, EPMC Brief) Additionally, the frequency of risk management meetings must coincide with program activities and the need for increased attention. For example, during the whole systems and subsystems trade processes, it is critical that risks be understood and managed as the system parameters and component capabilities are established. (Kepner, 2003) The risk management process, once approved and implemented, must be sustainable during all periods of SDD.

The Independent Risk Assessment Team (IRAT) conducted prior to the MSII decision indicated that formal risk management practices waned during periods just before significant program events (i.e., prototype roll out, major test events, etc.) during PDRR. Programmatic focus on achieving key milestones temporarily impacted "systems engineering processes" (Kepner, EPMC Brief) Systems engineering processes include risk management, requirements traceability, synthesis, etc. The IRAT recommended that process sustainability be a key characteristic of the SDD risk management process. Accordingly, the DRPM AAA directed that a program directorate assume risk management

process coordination consistent with the activities normally conducted during SDD.

The AAAV Team formalized a functional, program office directorate called Program Planning and Integration (PP&I). PP&I is responsible for the AAAV risk management plan and its implementation during SDD. The Program Integration Division Head is part of PP&I and is the program Risk Management Coordinator (RMC). Currently, both Government and GDAS members are refining the formal SDD risk management plan. The Government side of PP&I also focuses on Government-specific risks and advises the AAAV Program Management Team (PMT). The PMT consists of the PM, Deputy PM and Government Department Heads (i.e., Test and Evaluation Head, Manufacturing Head, Lead Engineer, PP&I, etc.).

The RMC chairs a bi-weekly meeting to address programmatic issues at the Department Head level called the Program Management Team (PMT) II. One of the focal points of the PMT II meeting is cross-functional risk communication and courses of action development. The purpose is to enhance communication of risks at the action officer level in the program and support decision-making at the next highest level, the PMT level. The PMT II advises the PMT on risk mitigation alternatives and resource impact for decision-making support.

The PMT II is well suited to analyze system-wide metrics to assess the success of mitigation activities. Additionally, the meeting is used as a venue to discuss award fee determinations and recommendations for upcoming contract performance assessment reviews.

The need for the PMT II is essential during the SDD stage when the program transitions from development to production activities. The increase in the number of program personnel makes communication even more critical. Additionally, the PMT II can perform many of the same functions that the Risk Resolution Board (RRB) did during PDRR without some of the drawback encountered with the RRB.

The RRB was an effective forum to analyze risk areas and serve as a decision-making board at the highest program office level during PDRR. The RRB process ensured dissemination of risks throughout the program from D Level IPTs to the PMT. However, amid the RRB's successes, two challenges eventually emerged that caused the AAAV program to adopt a different strategy during SDD.

First, because the RRB relied on the senior program leadership, its frequency of meeting became difficult during especially busy time periods of PDRR. The PDRR risk management process depended on the RRB to provide guidance and decision-making to function efficiently and consistently. The RRB, though a good idea and effective when executed, lacked the sustainability characteristic needed in SDD.

Secondly, some personnel from DRPM AAA and GDAS believed the RRB became a forum that did not always embrace risks as opportunities or foster an environment of open, non-attribution discussion. One GDAS employee said that the RRB became a "moot court." The result was a disincentive for IPTs or stakeholders to identify and introduce risks into the risk management process. The DRPM

AAA has responded by establishing the PMT II meetings, which serve as the Risk Coalition Team (RCT).

The RCT is “a team of Government personnel chartered as owners of the risk management process. Its primary purpose is to facilitate the creation and continuous operation of the risk management process.” (Draft DRPM AAA SDD Risk Management Plan, November 2002) The SDD RMC (Program Integration Branch Head) chairs the RCT. The RCT includes members from the following DRPM AAA directorates:

- PP&I
- Systems Engineering
- Logistics
- Testing
- Cost
- Engineering representatives
- DCMA representatives (Draft DRPM AAA SDD Risk Management Plan, November 2002)

The biggest difference between the RRB used in PDRR and the RCT used in SDD is the organization’s membership. The RRB consisted mainly of Division Directors whereas the RCT is comprised of the next lower level, the Department Heads or PMT II members. The benefit in the revised structure is that the RCT performs the majority of detailed risk analysis so they can then provide recommendations and courses of action to the PMT. The RCT can filter and solve many problems before coming to the attention of the PMT allowing the PMT to focus on higher level, Government-specific risk areas. The RCT meets bi-weekly as part of the PMT II meetings.

Another risk management technique the DRPM AAA used during PDRR was inviting an Independent Risk Assessment Team (IRAT). The purpose of the IRAT in PDRR was to evaluate the effectiveness of the program's risk management process and provide recommendations for SDD.

c. Periodic Risk Assessments

During PDRR, the AAAV Team conducted periodic internal and external risk assessments of the program's risk management process. Prior to Milestone II, the AAAV Team requested an independent risk assessment to evaluate the status of the program's technical risks and the risk management process prior to entry into the System Development and Demonstration (SDD) Phase.

EG&G, DRPM AAA's risk management support contractor, nominated a "three-member team of experienced engineers" to conduct the assessment. The Independent Risk Assessment Team (IRAT) was made up of EG&G Technical Services representatives and chaired by a representative from the Illinois Institute of Technology Research Institute who were also co-authors of the NAVSO Guide "Top Eleven Ways to Manage Technical Risks." (IRAT Report, September 2000)

The DRPM AAA tasked the IRAT with conducting an impartial assessment of the AAAV risk management program. The AAAV DRPM planned to integrate the IRAT's findings into part of the Milestone II Defense Acquisition Board (DAB) documentation. (AAAV Independent Risk Assessment Brief, March 2000)

The risk areas of interest were product and technical process risks. (IRAT Report, 2000) The AAAV Team

intended to use the IRAT findings to prepare for the upcoming Milestone II decision, identify technical and process risks associated with entering SDD and evaluate risk-handling procedures during PDRR. The DRPM provided IPT briefings and disclosed extensive technical and program documentation to facilitate the assessment.

The IRAT's methodology was as follows:

- Review related program documents, such as AAAV Risk Management Plan, SEMP, Management Plan, ORD, TEMP and both the Program Definition and Risk Reduction (PDRR) and EMD SOWs
- DRPM AAA IPT leads briefed the IRAT regarding implementation of risk management, issues/risks, and status
- Follow-up with interviews, discussions and data gathering in selected areas
- Prepare the IRAT report and out brief results to the DRPM AAA (IRAT, September 2000)

The objective of the assessment was to provide an objective overview of the program's risk management process and identify risk areas for entry into SDD.

The DRPM AAA found the IRAT to be extremely useful. The IRAT's objectivity on the risk management process provided invaluable feedback that allowed the AAAV program to shape its future SDD processes. The DRPM AAA intends to conduct periodic IRATs during SDD and in preparation for the LRIP decision.

The risk management process discussed in the preceding section analyzed and introduced several of AAAV's risk management techniques used during PDRR and SDD. The next analyzes one aspect of the AAAV program's use of the

contracting process to reduce programmatic risks and transfer risk from the Government to the contractor.

3. AAAV Risk Management Through the Contracting Process

Following the Milestone I decision, the Government awarded GDAS a Cost Plus Award Fee (CPAF) type contract for PDRR. Part of the second period award fee criteria was tied to GDAS' risk management process. Using contract award fees to provide contractors with incentives to proactively manage risk is an effective risk mitigation activity.

GDAS uses an award fee sharing system among its employees. Each GDAS employee earns a portion of the contract award fee. A graduated scale determines the various amounts. Employees earn percentages of award fees according to their position within GDAS. Award fee sharing, or profit sharing, in organizations motivates good behavior and provides incentive for all contractor employees to perform.

As a result of the award fee assessment, GDAS placed higher priority on risk management, from both a capability as well as training aspects. It was at this time that GDAS developed the VDD risk management applications and formalized the process used during PDRR.

The lesson learned was that contractually obligating and providing incentives for the Prime contractor to spearhead risk management efforts transferred some accountability for risk from the Government to industry. The Government was then prepared to evaluate the Prime Contractor's performance and reward them accordingly

through contract period award fees. The current SDD contract type is also a CPAF with award fee criteria tied to GDAS' risk management process. This also allows the Government to supervise GDAS' technical and system-level risk management while concurrently implementing a Government-specific risk plan.

GDAS' award fee sharing system sustains employee buy-in by financially rewarding its people for good performance. The DRPM AAA's contracting strategy is a good example of risk transference in DoD systems acquisitions. Once implemented, the AAAV risk management process relied heavily on Integrated Product Team (IPT) interaction and the Integrated Product and Process Development (IPPD) process. The next section analyzes the AAAV program's unique co-location and IPPD organization.

4. AAAV PDRR Co-Location and IPPD Process

The AAAV program's co-location at the Woodbridge, VA facility fosters continual communication and interaction between Government and GDAS personnel. This author interviewed both DRPM AAA and GDAS individuals concerning co-location. Both groups were in agreement that co-location allows for a great degree of real-time communication, which can reduce design risks, especially in the PDRR phase. Synthesis is a vital step in the systems engineering process and communication is imperative to effective synthesis, as decisions are being made with the full understanding of the Government through its counterparts on the IPTs. In addition to the communication benefits, both DRPM and GDAS personnel agreed that co-location helps each group understand the other's culture and therefore develop more effective working relationships.

In addition to the office space co-location, the vehicle assembly and production area located at the joint facility was of great value.

Co-location at the point of vehicle assembly allowed nearly seamless system integration activities. This facility reduced the risk of engineering and schedule problems by allowing GDAS and DRPM decision-makers to apply timely resources to friction points and fully understand the risks being mitigated.

During a visit to the Worth Avenue Technology Annex in Virginia, this author saw active duty Marines, representative of the intended end-users, providing input during design and assembly of SDD prototypes. This type of interaction greatly reduces the risk of systems not adequately accounting for logistics and supportability considerations during the design stages. Had GDAS and DRPM AAA not been co-located, it is doubtful that user representatives would have as much opportunity to provide input and feedback in the design stages. The alternative can result in time-consuming and costly system changes prior to fielding or once a system is fielded. Additionally, funding usually necessary for travel to bring IPTs or program leaders together is avoided by co-locating.

Co-location is synonymous with the principles of Integrated Product and Process Development (IPPD). Continual cross-functional area communication is a large part of the IPT process. Co-location allows the AAAV program to operate in an IPPD environment.

a. Integrated Product and Process Development (IPPD) and the AAAV Program

The AAAV Team's co-location facilitates the IPPD process and allows IPTs to work and interact on a frequent basis during SDD. The AAAV co-location as an enabler of the IPPD process "provides the foundation and communication conduits for the IPTs to maximize the effectiveness of every member of the organization." (Pollution Prevention: AAAV, October 2002) The Government and GDAS co-location facilitates IPT integration and interaction between the Government and company engineers, logisticians, product managers, and other functions. The program's emphasis on cross-functional coordination and efforts has and will result in significant schedule and cost risk mitigation and avoidance. In particular, the AAAV's dedication to reducing and, in some cases, eliminating environmental safety hazards (ESH) in the system's production will reap noteworthy Total Ownership Cost (TOC) and Lifecycle Cost (LCC) avoidances. Each AAAV IPT has an ESH representative. The following section is a case study of the benefits of IPT co-location and IPPD interaction.

b. Environmental Safety and Health (ESH) and the IPPD Process

Environmental Safety and Health (ESH) considerations may constitute significant programmatic risks. Such risks include safety of use, environmental impact of system use and exorbitant system disposal costs. In response to environmental risk considerations, the AAAV DRPM established an ESH Working Group (ESH WG). The ESH WG was tasked to "identify, evaluate, track and assist with mitigation of ESH hazards." (Pollution Prevention: AAAV, October 2002) The ESH WG's membership included both

Government and GDAS personnel who possess experience with ESH issues and environmental considerations. AAAV IPTs all have ESH representatives. The representatives ensure that ESH considerations and impact are part of all development and production decisions in the IPPD process.

The ESH WG created the “first ever Risk Reduction Process, embedded in the VDD, to identify, track, and eliminate ESH hazards.” (Pollution Prevention: AAAV, October 2002) The ESH WG identified and assigned “over five hundred ESH risk hazards” and “developed the ESH Database that provides the communication and tracking link for these hazards, the identification of the lead IPT for mitigation action, and tracking of the risk hazard resolution/acceptance.” (Pollution Prevention: AAAV, October 2002)

The DRPM AAA developed an ESH Awareness Session for all members in AAAV IPTs. (Pollution Prevention: AAAV, October 2002) The purpose of the ESH awareness session was to train and educate AAAV Team members on the potential risks associated with ESH.

The DRPM AAA drafted the system’s performance specifications to include a ban on all Class I and II Ozone Depleting Substances (ODS) in the design and manufacture of the AAAV. Additionally, the Government has contractually obligated both Prime and Subcontractors to eliminate the use of cadmium, lead, chromium and other environmentally hazardous materials in the production of the AAAV. The deletion of these environmentally harmful substances will reduce the risks of negative environmental impacts and high disposal costs.

Over the life of the AAAV program, the AAAV anticipates cost avoidance of $379.9 million in production and $238.9 million in Operations and Support (O&S) costs. (Pollution Prevention: AAAV, October 2002) The AAAV ESH initiatives have played a significant role in the projected cost avoidances through the application of the ESH Working Group (ESH-WG) and the Virtual Design Database.

The U.S. Army's Center for Health Promotion and Preventive Medicine (CHPPM) and the U.S. Navy's Explosive Safety Review Board (WSESRB) stated that the AAAV's "ESH-WG Risk Reduction Process is the best program of its type that they have encountered in DoD." (Pollution Prevention: AAAV, October 2002) The ESH-WG IPT representation ensures that ESH considerations are input throughout every design and manufacturing decision made for the AAAV. Through the system decomposition and iterative design process, ESH input in the IPT process enhances the likelihood that the system is built correctly the first time. This eliminates costly design or manufacturing process changes after the system is fielded or prior to demilitarization. The ESH-WG and ESH IPT representation are examples of the benefits of the IPPD process in weapon system developments. ESH risks were incorporated into the program's risk management process during PDRR in the same manner as all other risks managed by IPTs.

The relational VDD, discussed in preceding sections, allowed the entire AAAV IPT structure to have visibility on ESH risk identification, tracking, resolution and documentation issues. The VDD has resulted in effective horizontal, vertical and cross communications

concerning ESH risk handling. Because risks in VDD corresponded to WBS elements, the cause and effect relationships of ESH risks were easy to identify and assess.

The AAAV program has taken proactive measures to reduce the system's environmental impact. These measures will lead to cost avoidance over the life of the program as well as preserving the environment. The continual ESH assessment during the IPT process may have been less effective or ineffective had the AAAV program not been co-located during PDRR. The program's co-location and commitment to IPPD enabled ESH considerations to be part of design trade offs and CAIV analysis.

The AAAV performance specifications negate the use of several environmentally hazardous materials in the system's production. Offerors have had to develop and incorporate new, environmentally safe materials for integration into the AAAV. For example, cadmium was eliminated because of the presence of cyanide and other hazardous materials (HAZMAT) in the plating process. (Pollution Prevention: AAAV, October 2002)

Furthermore, the AAAV is testing a developmental, water-based Chemical Agent Resistant Coating (CARC) paint that will reduce Hazardous Air Pollutants (HAP) during manufacturing and repair of the system. The use of a water-based CARC paint is expected to save $2.8 million over the life of the program. (Pollution Prevention: AAAV, October 2002) The new CARC paint may represent enormous savings throughout DoD for systems that require CARC. Such developmental innovations may reduce future, developmental

system costs and reduce the risk of acquisition funds being diverted from procurement to support unanticipated O&S costs.

Working with the U.S. Environmental Protection Agency (USEPA), the AAAV program has also eliminated the use of all Class I and II Ozone Depleting Substances (ODS) and the majority of the USEPA's top seventeen hazardous materials. Savings as a result of the elimination of these hazards is expected to be in the tens of millions of dollars with even greater potential with DoD-wide adoption.

Reduction of HAZMAT initiatives during the AAAV's design and manufacture directly impacts Total Ownership Costs (TOC). The AAAV's avoidance of ODS and other HAZMAT will allow the system to enter its disposal phase without significant commitment of additional resources to make the disposal environmentally friendly. The AAAV's insistence that the Prime and Subcontractors use environmentally improved materials will result in savings in future systems LCC and Research, Development, Test and Evaluation (RDT&E) activities.

ESH risk mitigation is just one example of the AAAV IPPD process. Although other DoD programs that are not co-located effectively operate in an IPPD environment, the AAAV's co-location encourages continual, cross-functional area communication and constant interaction between GDAS and the DRPM AAA. In order to determine the effectiveness and supportability of ESH initiatives, the AAAV team needs to thoroughly test the system. The next section analyzes the AAAV PDRR test and evaluation plan.

5. AAAV PDRR Test and Evaluation

The aggressive developmental testing (DT) and early operational assessment (EOA) performed during PDRR will benefit the AAAV program during SDD and subsequent production and fielding. The results of the DT events and the EOA in PDRR allowed the AAAV team to identify what areas of the system required further developmental attention and testing. The PDRR test results helped determine the SDD test plan. On using test as a risk management tool, the DAU writes:

> Fixes instituted during early work efforts (Systems Integration) in the System Development and Demonstration (SDD) Phase cost significantly less than those required in later System Demonstration after the critical design review when most design decisions have been made."(Test and Evaluation Management Guide, November 2001)

Early testing can reduce the risk of run-away system delivery costs and expensive design changes late in the acquisition process. By conducting an EOA during a Combined Arms Exercise (CAX) in 29 Palms, California, the AAAV program combined developmental and operational test (OT) activities. DT under operational conditions, similar to those specified in the Operational Requirements Document (ORD), can reduce time and costs through concurrent testing. When conducted too late in a program's schedule, combined DT and OT events can result in OT failures and can impact milestone decisions. Conducted early, the program can identify risk areas and develop mitigation and test plans to fix and validate deficiencies. The DoD 5000.2-R encouraged combined DT and OT testing:

> A combined developmental test and evaluation (DT&E) and operational test and evaluation (OT&E) approach should be considered when there are time and cost savings. The combined approach must not compromise either DT or OT objectives. (DoD 5000.2-R, April 2002)

Data obtained from combined DT and OT events can be collected and potentially used in lieu of follow-on test events. Coordination with service test agencies and the Director of Operational Test and Evaluation (DOT&E) is important for obtaining and using test data.

Another lesson learned from the AAAV gunnery EOA was that crew training and experience on the weapon system is critical to successful test execution. The PMO is applying this lesson learned to the test crew-training plan during SDD.

In addition, the program office conducted extensive testing on the MK46 weapons station to include a gunnery EOA. The MK46 lethality tests met or exceeded all ORD requirements during PDRR. In the course of testing, the AAAV program identified areas that will require additional study and follow-on testing in SDD such as ventilation and gunner training. This knowledge helped the DRPM AAA develop the SDD test plan and concentrate on specific system components prior to additional OT.

Other than the expected system performance-oriented test events, the AAAV program conducted extensive life cycle support testing during PDRR.

Life cycle support testing included logistics demonstrations, maintainability demonstrations, mean time to repair (MTTR) demonstrations and human factors

engineering testing. The significance of the AAAV's PDRR test plan was its emphasis on life cycle support. Life cycle support considerations will drive the AAAV's life cycle costs (LCC). Some estimates report that nearly 75 – 80% of a system's overall cost is assumed during Operations and Support (O&S).

Test events designed to validate ORD-specified MTTR or operational availability parameters can reduce LCC and poor operational availability. This can be achieved by including user juries during logistics demonstrations and MTTR demonstrations. User juries can identify system re-design recommendations to make the system more maintainable. The system's supportability will drive its operational availability. Decreased repair requirements and cycle times will reduce maintainability costs and time. The result will be a supportable and available system for the intended user.

Logistics can be a primary system cost driver during O&S. Thoroughly testing a system during PDRR and SDD for supportability, reliability and maintainability can greatly reduced O&S costs and increases operational availability by identifying supportability risks early on in the program's schedule. Reducing the risk of unanticipated O&S costs can protect resources intended for pre-planned program improvements (P3I) and new developmental systems.

The SDD test plan will focus on verifying design improvements identified in PDRR by testing an expected nine SDD prototypes. (Developmental Testing Brief, November 2002) The emphasis will be on addressing design changes

identified in PDRR and conducting OT activities in order to meet Low Rate Initial Production (LRIP) entrance criteria.

E. SUMMARY

This chapter analyzed the data presented in Chapter IV of this thesis. This chapter discussed the author's purpose of research and research methodology. The primary purposes were to analyze and discuss the AAAV PDRR risk management strategy and connect the lessons learned in PDRR to the SDD risk management techniques.

This chapter discussed AAAV PDRR information technology tools: VDD, VINTEGRA and LCIS. The lesson learned from PDRR was that information technology tools could be force multipliers in managing risk. VDD served as a central repository, or risk database. VDD risk management applications facilitated the formal risk management process. VDD's automatic notification system enabled communication across program functional lines. Shortfalls in VDD have led to the development of LCIS during SDD. LCIS aims to create a risk management tracking application that emphasizes trend analyses, reporting and program-wide risk management.

VINTEGRA continues to reduce system production risks by identifying integration and assembly and production refinement requirements. Additionally, VINTEGRA will reduce cost risks in the development of IETMs. The program office expects IETMs to reduce maintenance delay times thus improving operational availability and logistics strains during O&S.

The AAAV PDRR risk management process was effective. However, the program office learned valuable lessons from

its process and is applying lessons learned to the process used in SDD. Namely, the DRPM AAA and GDAS instituted the PP&I directorate. One of the functions within PP&I is the overall risk management process. The program implemented the PMT II bi-weekly meetings. Risk management is a statutory PMT II agenda item. Through the PMT II, the RCT will manage program risks and develop courses of action to present to the program leadership for decision support.

During PDRR, the Government incentivized risk management through the use of an award fee. The CPAF contract type provided financial incentives for GDAS to execute sound risk management practices. The Government awarded GDAS a CPAF type contract for SDD with risk management tied to award fee criteria, as well. Including financial incentives in contract award fee criteria is an effective technique to transfer risk from the Government to a Prime contractor. Both entities gain from effective risk handling as a result.

The DRPM AAA has co-located with its Prime contractor, GDAS, in Northern, Virginia. The AAAV program co-location has facilitated continual communication and interaction between Government and Industry personnel. The close working relationship is consistent with IPPD principles. The AAAV program’s IPPD process has benefited from the communication advantages provided by co-location.

Finally, the AAAV PDRR test plan included OT activities combined with DT. The aggressive test plan allowed the program to identify areas that will require greater attention during SDD. The results of the PDRR DT, OT and EOA have helped shape the SDD test plan. The SDD

test strategy is to fix design deficiencies discovered during PDRR and prepare the system to meet LRIP entrance criteria.

The next chapter concludes this thesis. The purpose of the conclusion is to discuss how the AAAV SDD risk management strategy reflects the lessons learned from the PDRR risk management approach. Additionally, the chapter discusses which elements of risk management practices the AAAV program is benefiting from most and provides recommendations for managing risk in developmental weapon systems.

VI. CONCLUSION

A. INTRODUCTION

This chapter provides conclusions and recommendations drawn from the analysis of the Advanced Amphibious Assault Vehicle (AAAV) Program Definition and Risk Reduction (PDRR) and System Development and Demonstration (SDD) risk management strategies. The benefit of this research is to illustrate risk management techniques used in Department of Defense (DoD) weapon system procurement and development through a study of the AAAV's transition from PDRR to SDD.

B. CONCLUSIONS AND RECOMMENDATIONS

This section discusses conclusions regarding risk management procedures used by the AAAV program during SDD. Based on the conclusions, this chapter offers recommendations for managing risk in DoD developmental programs.

1. AAAV Information Technology Tools

a. Conclusions

Weapon system programs that use Information Technology (IT) tools or applications to complement risk management processes can effectively manage many of the risk areas discussed in this thesis. The AAAV program used the Virtual Design Database (VDD) during PDRR to augment the formal risk management process.

VDD enabled the program management office (PMO) to identify, categorize, communicate and file risks through a relational database available on the program's Intranet. Acknowledging the need to expand VDD's capabilities to manage risks during SDD, the AAAV PMO is developing Life Cycle Information System (LCIS). LCIS expands on VDD by

incorporating applications that assist in tracking risk trends and conducting variance analysis to assess mitigation efforts: a capability the PMO recognizes as important in managing risks in SDD. LCIS, a web based application, will improve the program's communications by making the application available to sub contractors and potentially to remote test locations, as well. It is being developed to support the anticipated future needs of the AAAV as a Program Management Office of Life Cycle Support (PMOLCS).

The benefits that IT applications provide PMOs are numerous. LCIS will expand on VDD's ability to communicate emerging risks, track risk mitigation activities and conduct risk analyses to support program level risk management efforts.

b. Recommendations

Based on the conclusions discussed above, this thesis offers recommendations for managing risk in weapon system programs through the use of IT applications:

- Develop and employ electronic resources to facilitate and complement the program's formal risk management methodology
- Make this IT resource available to all program stakeholders: Government, Support Contractors, Prime and Sub Contractors
- Ensure all users are properly trained
- Keep the application simple
- The application should support the program's specific goals or efforts in an acquisition phase
- Anticipate desired expansion of the tool's capabilities to satisfy program requirements in later program phases

- When practical, employ a dedicated program Chief Information Officer (CIO) to oversee IT initiatives

2. The Joint Government-General Dynamics Risk Management and Resolution Process

a. Conclusions

A weapon system's risk management process should be simple and sustainable. The success of a process will depend in large part upon the degree to which its implementation does not detract from concurrent program demands. Risk management is a continuous part of the system development and acquisition process. All activities in the process should add measurable value to the program's development and production. Risk mitigation activities need to be tied to metrics to evaluate progress and efficacy of the efforts.

The formal risk management process should focus on what is important to the program: meeting user requirements given time and resource constraints. The process should involve senior leadership participation while maintaining an environment that encourages the airing and resolution of risks. It should reward initiative and acknowledge the value of responsible risk acceptance while insisting on accountability and ownership of risk and its mitigation.

b. Recommendations

The analysis and conclusions of the AAAV's risk management and resolution process drive the following recommendations:

- The risk management process should be simple
- A program management office should consider using a risk primer to familiarize and train personnel in the risk management process
- A formal risk management process should be sustainable given program office workforce strength and anticipated demands
- Risk management activities should add measurable value to the program
- The establishment of a program directorate or division to oversee risk management can help to coordinate efforts, track risk trends and liaise with leadership
- Metrics should be developed and employed to assess the success or failure of mitigation efforts
- Program offices should consider periodic, external risk management assessments

3. Risk Management Through the Contracting Process

a. Conclusions

Contract incentives tied to a Prime contractor's risk management process are an effective tool to transfer risk from the Government to its industry counterpart. The Government program office ultimately assumes responsibility for the success or failure of a system's risk handling. However, tying financial incentives for the contractor to develop and implement effective risk management processes can result in improved contractor performance. GDAS' award fee, or profit sharing structure resulted in increased employee buy-in to the AAAV risk management process during PDRR. As a result, the Government continues to provide contractual award fee incentives for GDAS to execute a proactive risk management process in SDD.

b. *Recommendations*

As a result of the success the DRPM AAA has had in tying risk management to GDAS' contract award fee plan, this thesis offers the following recommendations concerning risk management through the contracting process:

- Transferring risk from the Government to contractors through financial incentives can be an effective method to achieve desired results or levels of effort
- Profit-sharing organizational structures can incentivize good performance and employee buy-in

4. Government and Prime Contractor Co-Location

a. *Conclusions*

The Marine Corps/GDAS co-location on the AAAV program has created an environment of continual communication between Government and Prime contractor personnel across traditional program lines. The ease of communication and problem resolution decreases administrative delay times and miscommunications between Government/contractor counterparts. Co-location at the point of vehicle design, testing, assembly and prototype production enhance the IPPD process by providing an environment for teams to truly integrate.

The benefits of AAAV's co-location are evident in the proactive management of risks such as those in Environmental Safety and Health (ESH). Co-location allows Government and Industry personnel to identify and appreciate different organizational cultures. Understanding these differences enables both the Marine Corps AAAV team and GDAS to work towards establishing the most productive work environment for the benefit of the program.

b. Recommendations

Recommendations concerning Government PMO and Prime contractor co-location are as follows:

- Co-location facilitates communication and the IPPD process
- Co-located PMOs can save time and money in a system’s developmental stages
- User representatives involved on a regular basis in a system’s design for suitability can prevent costly and avoidable changes

5. Test and Evaluation

a. Conclusions

The AAAV’s test program in PDRR included combining DT and OT test events in a challenging operational environment. The lessons learned from the test results allowed the program office to know what its strengths and deficiencies were entering SDD. This knowledge shaped the SDD test plan to prepare the system to meet LRIP entrance criteria. Testing the system aggressively and early in the test plan reduced the risk of being forced to combine risky DT and OT events prior to a Milestone decision because of schedule compression. Including user juries and Fleet Marine Force (FMF) Marines in the EOA provided the program with relevant user feedback early in the system’s design stages when changes were possible and less costly. The AAAV’s emphasis on life cycle support testing in PDRR represents the Marine Corps’ goal of reducing total ownership cost of the AAAV.

b. Recommendations

Based on the AAAV’s test history, this thesis offers the following recommendations:

- Conduct logistics and life cycle support tests with user juries early in the system’s development to avoid costly changes and reduce the risk of fielding an unreliable or difficult to maintain system
- Combining DT and OT test events during PDRR allows a program to refine its SDD test plan to successfully meet LRIP entrance criteria
- Include user juries in DT and OT test events whenever feasible to solicit feedback early in the system’s development
- Ensure all personnel involved in test events are thoroughly trained and have sufficient experience to be able to execute required activities at an acceptable level of performance.

This chapter concludes the thesis by addressing what conclusions and recommendations can be made from the analysis of data presented in previous chapters. The following section provides suggested areas of further research in risk management and in the AAAV program.

C. AREAS OF FURTHER RESEARCH

The following areas of further research are suggested to expand upon this analysis of current DoD risk management practices in the development and procurement of complex weapon systems:

- What impact do the revised DoD 5000 Series acquisition guidelines have on DoD developmental weapon system risk management practices?
- How do the revised DoD 5000 Series acquisition guidelines impact the AAAV program prior to and following Milestone C?
- What conclusions and recommendations can be made from an analysis of the AAAV program’s SDD risk management strategy?
- What conclusions and recommendations can be drawn from an analysis of co-located and detached

program management offices regarding the impact of co-location on the IPPD process?

- What risk management techniques are being used to manage software intensive programs?
- What metrics can be used to evaluate software development and are they effective?

APPENDIX. LIST OF ACRONYMS

AAAV	Advanced Amphibious Assault Vehicle
AAV	Amphibious Assault Vehicle
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
ATD	Advanced Technology Demonstration
CAD	Computer Aided Design
CAIV	Cost as an Independent Variable
CAN	Center for Naval Analyses
CARC	Chemical Agent Resistant Coating
CAX	Combined Arms Exercise
CHPPM	Center for Health Promotion and Preventive Medicine
CIO	Chief Information Officer
CPAF	Cost Plus Award Fee
CSC	Computer Systems Corporation
DAB	Defense Acquisition Board
DAD	Defense Acquisition Deskbook
DAU	Defense Acquisition University
DoD	Department of Defense
E&MD	Engineering and Manufacturing Development
EPRS	Electronic Problem Resolution System
DRPM	Direct Reporting Program Manager
DRPM AAA	Direct Reporting Program Manager Advanced Amphibious Assault
DT&E	Developmental Test and Evaluation
ECP	Engineering Change Proposal
EOA	Early Operational Assessment
EPMC	Executive Program Managers Course
ESH	Environmental Safety and Health
EV	Earned Value

EVM	Earned Value Management
EVMS	Earned Value Management System
FMF	Fleet Marine Force
GAO	Government Accounting Office
GDAS	General Dynamics Amphibious Systems
GQM	Goal, Question, Metric [paradigm]
GSAM	Guidelines for Successful Acquisition of Software-Intensive Systems
HAP	Hazardous Air Pollutants
IETM	Interactive Electronic Technical Manual
I-IPT	Integrating Integrated Product Team
I&A	Integration and Assembly
IOC	Initial Operational Capability
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
IRAT	Independent Risk Assessment Team
IT	Information Technology
ITP	Integrated Test Program
JTAV	Joint Total Asset Visibility
KPP	Key Performance Parameter
LCAS	Landing Craft Air Cushioned
LCC	Lifecycle Cost
LCIS	Life Cycle Information System
LRIP	Low Rate Initial Production
MCCDC	Marine Corps Combat Development Command
MDA	Milestone Decision Authority
MNS	Mission Needs Statement
M&S	Modeling and Simulation
MS	Milestone
NEPA	National Environmental Protection Act
NMS	National Military Strategy
NSS	National Security Strategy

OMFTS	Operational Maneuver From the Sea
ODS	Ozone Depleting Substance
ORD	Operational Requirements Document
O&S	Operations and Support
OT&E	Operational Test and Evaluation
PC	Personal Computer
PDRR	Program Definition and Risk Reduction
P3I	Pre-planned Program Improvement
PM	Program Manager
PMO	Program Management Office
PMOLCS	Program Management Office of Life Cycle Support
PMT	Program Management Team
PP&I	Program Planning and Integration
RCT	Risk Coalition Team
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposal
RM	Risk Management
RMC	Risk Management Coordinator
RMP	Risk Management Plan
RRB	Risk Resolution Board
SDD	System Development and Demonstration
SEI	Software Engineering Institute
SOO	Statement of Objectives
SOW	Statement of Work
SSP	Source Selection Process
TDP	Technical Data Package
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TOC	Total Ownership Cost
TPM	Technical Performance Measurement
USEPA	United States Environmental Protection Agency

VDD	Virtual Design Database
VINTEGRA	Virtual Integration and Assembly
WATA	Worth Avenue Technology Annex
WBS	Work Breakdown Structure
WG	Working Group
WSESRB	Weapon System Explosive Safety Review Board

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9. Marine Corps Tactical Systems Support Activity
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10. Direct Reporting Program Manager, Advanced Amphibious
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